

SCIENCE IN MODERN INDUSTRY

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FOREWORD

WE are awed today by the discoveries of Galileo, of Pasteur, of Faraday. They are far enough removed from us in time to permit us to see their work in perspective. We are now able to see the working out of the results of their researches. We see their discoveries expressed not only in practical affairs, but as a basis for later investigations and discoveries, that in turn have made over human thinking and human living. We can see that their scientific discoveries are entitled to be called "revolutionary."

We can perceive the revolutionary nature of these early discoveries nowhere so well as in industrial life where the resulting transformations have been most spectacular. The nature of the problems that concerned men one hundred and fifty years ago has been transformed by the silent mutations of science.

What most of us fail to realize is that revolutions in industry are being effected by science and the scientific method today with a speed and over an area that make the efforts of one hundred and fifty years ago seem puny. Not only do people generally fail to realize the social significance of this continuing scientific revolution, but they know only the most superficial facts concerning it. Small wonder that we are only half-conscious of our debt to science and the scientific method.

The purpose of this volume is not to present a cross section of the scientific work that is being carried on in modern industry, for that would require infinite space, but to present briefly some important examples of that work and to suggest something of the breadth of the area in management practice that is being influenced by science and the scientific method. When society comes to have a true picture of its fundamental dependence upon science and scientific work, then the basis for enduring progress will have been laid. And when management comes to realize that, it, too, will elevate its standards and accomplishments only as every phase of its work comes to be dominated by the spirit and method of science. In the words of Dr. Little:

The practical man too often confounds science with mere theory and so sees little place for it in his business. But science, in its industrial applications, is as intensely practical as a market report or a balance sheet. It represents the accumulated experience and organized knowledge concerning the behavior of things, which thousands of the world's best minds have acquired by the incessant questioning of nature for more than a hundred years. As such the manufacturer ignores it at his peril. An enlightened self-interest should lead him to welcome its teachings and generously support research, for research is the mother of industry.

JOSEPH H. WILLITS

The Contribution of Science to Manufacturing

By A. D. LITTLE

Arthur D. Little, Inc., Cambridge, Mass.

ALTHOUGH agriculture is properly regarded as the basic industry, the money value of its product in the more progressive countries is greatly exceeded by that of manufactures. In the United States, for example, the two classes of products stand in about the relation of 16 to 44 in billions of dollars. Many causes have, of course, contributed to bring about the change from an agricultural to a manufacturing status, but the underlying and controlling factor has unquestionably been the extraordinary development of science during the last one hundred and fifty years. Even now, however, it is only in comparatively rare instances that the individual manufacturer realizes his obligation to the scientist or appreciates the extent to which further benefits may still accrue to him through the application of the scientific method to his own business. A considerable number of our larger corporations have indeed found it profitable to conduct research upon the grand scale, and they are, without exception, conspicuous for their success. The great majority of manufacturers are, however, little concerned with the fundamental scientific basis of their industry. As a consequence, major improvements very commonly originate outside the industry or in the laboratories of their more enlightened competitors, and often with disastrous result to long established businesses. It is difficult for candles to compete with electric lights.

Among the essentials for successful manufacturing are reasonably cheap power, sufficient supplies of suitable raw materials, effective and controllable processes, efficient equipment and

machines, adequate facilities for transportation, and, finally, such external purchasing power as shall ensure absorption of the product. In so far, therefore, as science may have benefited manufacturing we should expect it to have contributed to some or all of these essentials.

IMPORT OF THE STEAM TURBINE

The industrial position of a nation and the productive capacity of its workers are determined in large measure by the per capita units of energy that it can make available to them. The invention of the first crude steam engine transferred industry from the cottage to the factory by making energy available in what were then large units. That steam power is now available in units incomparably greater is chiefly due to the scientific work of Rumford, Joule, Carnot, Rankine, and the many others, which supplied the thermodynamic data required for the design of engines of many types and of constantly increasing size.

Behind the steam turbine is a long story of research. There were problems of corrosion and erosion which required the development of special steels and alloys. The high speed of rotation disclosed unsuspected strains. In the laboratory of the General Electric Company these were studied in many ingenious ways. Rotors of plaster of Paris were revolved until they burst and when in the act of bursting were photographed by an electric spark. Other rotors of soft rubber were given a heavy coat of paint, and similar photographs during revolution disclosed the lines of strain by the cracks in the

painted surface. In similar rotors the soft rubber was pierced with numerous circular holes. Spark photographs showed, by the elongation of these holes, the direction and magnitude of strain, and, curiously, the longest axis of the holes was not radial, as one might expect from the centrifugal forces developed, but concentric with the circumference of the rotor. Still other photographs revealed unsuspected wave motions or "flag waving" in the buckets of the turbine and led to means for its correction with the result that turbo-generators of 80,000 h. p. are now in operation.

But steam engines and turbines will not operate without steam, and to raise steam requires fuel. For his supplies of fuel the manufacturer is no less deeply indebted to the geologist and the chemist than to the miner. Geology supplies the fundamental data which permit the successful mining of coal and the sinking of oil and gas wells. Chemistry furnishes the explosives which increase by many times the output of the individual miner. It protects his life by the Davy safety-lamp, provides oxygen and gas masks and other rescue equipment, determines the causes of mine explosions and suggests means for their avoidance, defines the quality of the coal itself by chemical analysis, and permits its purchase on exact specifications.

Chemistry contributes no less efficiently to the economical use of fuel. Combustion is a chemical process that can only be properly regulated by due regard to chemical laws. Through ignorance of these laws many manufacturers spend far more money in heating up the atmosphere than they do in raising steam.

Many important industries are based upon the processing of coal, and to them the contribution of chemistry is greater still. The coal gas of Mur-

doch, the water gas of Lowe, the producer gas of Mond, the coke ovens of Otto, the low-temperature carbonization processes of Parr, Piron and many others, the recoveries of ammonia for the fertilizer industry and for refrigeration, and the wonderful story of the coal-tar products, which range from roofing and road material, through dyes of every hue, to perfumes and synthetic drugs, bear witness to the productive effort of thousands of chemists working in hundreds of laboratories in many lands.

The scientific study of the fundamental laws and theory of hydraulics has raised the efficiency of hydraulic turbines from 76 per cent in 1904 to 93 per cent in 1922 and made possible the design and operation of units of 70,000 h. p. Studies of the laws of heat transfer and the relation thereto of gas velocity and turbulence of flow have similarly raised the output and efficiency of steam boilers.

A laboratory experiment of Oersted disclosed a relationship between electricity and magnetism for he observed that an electric current deflected a compass needle. Later, another laboratory experiment, this time by Faraday, proved that a moving magnet can generate a current, for the needle of his galvanometer swung as he moved a magnet through a coil of wire connected with the instrument. Doubtless to the manufacturers and bankers of those times these seemed trivial occurrences, but they were more momentous to the interests of both than the Napoleonic Wars. On them are based our electrical industries with a book cost of \$25,000,000,000, the great central-station plants for generating power, the transmission lines which convey the current at voltages as high as 220,000 for hundreds of miles, subdividing and distributing energy to factories, municipalities and homes, and finally those

quiet, efficient electric motors which strip the factory of its belts and shafting.

The application to power generation of the discoveries of science has so augmented the energy supply that there is now available for every man, woman and child in the United States the equivalent of 60 man power, and that portion of this energy that is distributed as electricity is available at an average cost of \$4 per man-power year. It probably cost our ancestors more to keep a turnspit dog. The manufacturer whose wheels are turned by this unseen and unfed population of workers may well consider his obligation to science which created them.

The proper lighting of a factory may easily increase its output from 5 to 20 per cent. One would, however, not care to light a cotton mill with candles. The development of electric lighting began with Sir Humphrey Davy, who, in the laboratory of the Royal Institution, produced an arc between points of charcoal and raised a platinum wire to incandescence by the passage of an electric current. Years later Swan, in England, and Edison, in this country, after long experiment, brought out the carbon lamp. More research in the laboratories of the General Electric Company gave us the tungsten filament, and still more research produced the argon-filled lamp. Today a given amount of light is available to the manufacturer at 5 per cent of its cost in 1880.

RESULT OF RESEARCH IN RAW MATERIALS

Nowhere has the bounty of science to the manufacturer been more conspicuous than where his supply of raw materials is concerned. It has developed new sources of supply for old materials, found substitutes for those of growing scarcity, and made available for his

purposes thousands of new materials, the product of the laboratory. In doing this it has laid the foundation of countless new industries, which, in turn, consume the products of those already established.

Industry looks to agriculture for much of its raw material, and the farm is correspondingly dependent on the factory for fertilizers, insecticides, agricultural machinery, and home supplies. Fortunately for both farmer and manufacturer, science has long been intensively applied to the study of agricultural problems in the laboratories and greenhouses and on the testing plots of universities, government departments, and agricultural experiment stations. Botanists have searched the earth for hardier or more prolific species; chemists have analyzed soils without number to determine the relation of composition to plant growth; entomologists have studied the life cycle of insect pests; meteorologists have for years read thermometers, barometers and anemometers, and sent their instruments above the clouds; biologists have studied microscopic fungi, cultivated bacteria, and developed serums—all to the end that agriculture should be established upon a surer and more efficient basis. An Austrian monk applies the scientific method to the growing of peas and discovers the laws that control heredity in plants and animals. Because of all this the cotton spinner has better grades of cotton; the beets coming to the refinery carry 18 per cent of sugar instead of 6 per cent; tobacco plants grow 30 per cent more leaves fit for wrappers; wheat has more gluten; corn and potatoes more starch; hogs are heavier, cattle bigger, and hides larger and better.

To many industries the character of the water supply is a matter of vital concern. Here, again, the chemist, the bacteriologist, the engineer and the me-

teorologist have combined to assure to the manufacturer an adequate and suitable supply. To them he is indebted for studies of rainfall and stream flow, for filtration and sedimentation systems, for methods of water softening and the sanitary control of water supplies which protects the workers against disease.

Without metals there could be no manufacturing in the modern sense, and to the winning and working of metals science has contributed so liberally that mankind is now supplied with them in an abundance and variety never before approached. The Bessemer process made steel so cheap and widely available that industry and transportation expanded to an order of dimensions altogether new. Its benefits were extended by the Thomas and Gilchrist process for the treatment of phosphatic ores and by the open-hearth steel of Siemens. The decades 1870-1890 were marked by great advances in metallurgy and extraordinary activity in metallurgical science to the great benefit of the world today. In 1882 Hadfield brought out manganese steel, the first of the important alloy steels, although Faraday, in 1822, had produced many remarkable steel alloys in the Sheffield works of Sanderson. Today the manufacturer has available for his special requirements steels alloyed with silicon, tungsten, vanadium, molybdenum, nickel, chromium—each with distinguishing and often remarkable qualities. The toughness and resistance of manganese steel led to its adoption for the helmets of seven million soldiers of the Allies. The low hysteresis steel of Hadfield is estimated to have saved, since 1889, \$340,000,000 by reducing energy losses and permitting better design in electrical equipment. Special steels for high-speed cutting tools retain their edge even at low red heat; others are stainless under severe con-

ditions favorable to corrosion. The qualities and properties of steels and alloys generally are now controlled in hundreds of laboratories by analyses and physical tests, and by microscopical studies, which reveal structure and the results of heat treatments. X-ray photographs disclose unsuspected flaws in castings, and X-ray dispersion patterns make manifest the very arrangement and spacing of the atoms themselves.

Electrochemistry has founded great industries and made available to the manufacturer pure copper, cheap aluminum, magnesium, sodium, and other metals and alloys with wide range of useful applications. It supplies phosphorus, alkali, bleaching powder and chlorine, calcium carbide, and the acetylene utilized in the acetylene torch for cutting metals and as the raw material for many synthetic products. From the electric furnace come ferroalloys, better grades of brass, artificial graphite for electrodes and lubrication, and powerful new abrasives as carborundum and alundum. At the other end of the thermometric scale science has produced the liquefied gases. Chlorine, which Faraday reduced to liquid in a glass tube, is now shipped in tank cars. Ammonia, carbonic acid and sulphurous acid are liquefied and trucked about in cylinders, and liquid air, so recently a scientific marvel, has become a commonplace of industry and the commercial source of nitrogen, argon, neon and cheap oxygen.

Industries of vast extent and extraordinary variety owe their origin to Schonbein's discovery of nitrocellulose. Decades of intensive research have resulted in the establishment of great plants for its conversion into gun cotton, smokeless powder, celluloid, photographic films and artificial leather. From it de Chardonnet first produced artificial silk. In another form it con-

stitutes the impression surface in the fast, perfecting presses of our newspapers and in its latest aspect is everywhere in evidence in the finish of our motor cars. The influence of this new development upon the paint and varnish industry is likely to be profound, and the example it furnishes of the readjustments which research compels has a significance that no manufacturer can afford to ignore.

The development of Bakelite carries an equally significant message to those who conduct their business with an open mind. The manufacturer who desired a new plastic material, which should be mechanically strong, resistant to solvents and corrosion, infusible, and of high insulating power, would hardly select as his raw materials carbolic acid, which is liquid, soluble, corrosive and highly poisonous, and formaldehyde, an irritating gas, soluble in water. Yet that is just what his knowledge of organic chemistry led Baekeland to do with the happy result that the world is now in possession of a new plastic of unique properties, which is already employed in a thousand applications to purposes of utility and ornament.

If the textile industry depended today upon grass bleaching, as was once the case, most of New England would be cloth-covered. Fortunately, it now relies on chlorine, though with little acknowledgment of its indebtedness to Scheele, Tennant and Weldon. A little touch of chemistry gave to the industry mercerized cotton with its surprising lustre. More chemistry produced artificial silk, more brilliant than the natural product and now available in far greater quantity. From black, forbidding coal tar chemists have supplied the textile colorist with dyes to the number of nearly a thousand and covering the whole range of the spectrum. Indigo and alizarine, once agri-

cultural products of large importance, are now better and far more cheaply made in factories because chemists solved the complex riddle of their structure and synthesis.

"UNIT OPERATIONS"

Efficient manufacturing requires efficient processes for the conversion of raw materials into products of higher value. Practically all such processes can be resolved into a sequence of so-called "unit operations," and the efficiency with which each of these is conducted determines the efficiency of the process as a whole. The control of material and energy made possible by science has enormously increased the efficiency of most of these unit operations and permitted a corresponding increase in the size of the units in which they are conducted. If the operation involves heating, the manufacturer has at his command a diversity of method and range of temperatures beyond the imagination of his predecessors. He may heat by powdered coal or oil or gas, by steam at pressures up to 3,200 pounds, by oil bath, alloy bath, or mercury vapor, by surface combustion or the oxy-acetylene torch, by electrical resistance as in spot welding and electric heaters, or he can attain temperatures reaching to 6,500° F. in the electric furnace. For the accurate control of temperature science has supplied registering thermometers and pyrometers, seggar cones, and automatic instruments.

If the separation of materials is the object of the unit operation, science has supplied the data for many general methods now in common use by manufacturers. In air separation, for example, the curves described by the particles of the material undergoing treatment determine the thoroughness of the separation, and the form of these curves depends upon the relations ex-

isting between the pull of gravity, the velocity of the air stream, and the size and specific gravity of the particles as affecting resistance to air. Highly scientific studies are similarly involved in the electrostatic separation of solids from solids or of solid or liquid particles from gases. The successful concentration of ores by the flotation process presents a series of difficult problems in physical chemistry, and the magnetic separation of ores involves electrical and physical problems of another sort. One might, in fact, go through the whole list of separation methods from sedimentation and filtration to distillation and the use of the supercentrifuge and show, in case of each, the controlling contributions of science.

It may be that some workers of metals still conduct their unit operation of cutting without regard to the mathematical equations and the thirty thousand tests of Taylor and his assistants. If so, it may be assumed with safety that they are doing their work far less effectively and at much greater cost than their competitors who have learned that science pays.

DISCOVERY OF NEW PROCESSES

But science has not only revolutionized most of the unit operations of the manufacturer. It has also provided industry with a vast number of new processes, upon which, in many fields of production, great enterprises are now based. Some of these, like the aluminum process, discovered by Hall in the laboratory of Columbia University, the syntheses of the coal-tar colors, which began with Perkin's discovery of mauve, and the long series of industries based upon nitrocellulose, have been already noted. Thousands of others must necessarily be ignored, but their far-reaching importance may be indicated by a few examples.

Many chemists, and notably Saba-

tier, have studied the curious influence of certain materials, as platinum black and finely divided nickel, in causing reactions to take place in which they themselves are apparently not affected. Such chemical parsons, or catalysts, are now utilized with remarkable effect in many lines of industry. Under suitable conditions of heat and pressure hydrogen and nitrogen combine in the presence of a catalyst to form ammonia, as in the celebrated Haber process. Sulphuric acid of highest concentration is made in the so-called contact process by a method which consists essentially of passing the gas from burning sulphur mixed with air over heated platinized asbestos. Fish oil, which commonly develops an offensive odor, is deodorized and converted into a solid fat valuable as soap stock by causing it to combine, in the presence of finely divided nickel, with a small proportion of hydrogen. By a similar method of hydrogenation wholesome edible fats are prepared in enormous quantities from coconut, cottonseed and peanut oils. So long ago as 1916 the sale of one of these American products amounted to 60,000,000 pounds a year, and more recently a single plant in England was thus converting 2,000 tons a week of coconut oil. Last year a New Hampshire company purchased 65,000 acres of land in Florida, on which to grow peanuts to ensure its supply of peanut oil for hydrogenation. Such are the substantial businesses that are frequently based on simple chemical discoveries.

Because starch, by treatment with sulphuric acid, was found to be converted into a sugar known commercially as glucose, 50,000 bushels of corn pass daily through a single plant. Because certain complex organic chemicals greatly accelerate the vulcanization of rubber, the capacity of a tire factory is increased threefold.

Maxwell develops a mathematical theory of light, which indicates the possibility of ethereal waves vastly longer than those of light. Hertz detects their presence, Marconi utilizes them in wireless telegraphy, De Forest and many others develop radio telephony, and manufacturers the world over are now called upon to supply radio equipment to the value of hundreds of millions of dollars a year.

Bacteriology, as applied by Pasteur, saved the wine industry of France. Today its teachings guide the tanner of leather and the packer of foods as they do the physician and the surgeon. In the fermenting vats of new distilleries bacteria are producing millions of gallons of special solvents.

RELATION OF SCIENCE TO MACHINERY

But manufacture requires machines as well as materials and processes, and the machine is properly regarded as the result of invention rather than of science. Nevertheless, the design, construction and operation of machines involve innumerable problems that are only solved by the aid of science. Some one must study with the aid of all the refinements of the laboratory the properties of metals, their strength, elasticity and tendency to fatigue; the laws of frictional contact; the characteristics of special alloys for use as bearing metals; and the phenomena and materials of lubrication. It takes science to support, on a single bearing, a 70,000 h. p. vertical turbine, weighing 1,250,000 pounds. Intricate mathematical problems must be solved before dynamic balance and freedom from vibration are secured in fast running modern machines.

The refinement of measurement made possible by science has become an absolute essential of machine design. The maximum variation allowable in

a set of ball bearings is 1/10,000th of an inch. Mass production demands that the parts of an intricate mechanism like the automobile be interchangeable, and such identity requires the utmost nicety of dimensional control. As the ultimate court of appeal science has set up the interferometer, which measures waves lengths of light. It has made possible the construction of gauges with an error less than 1/100,000th of their stamped dimensions and of reference scales accurate to 1/1,000,000th. The stresses developed in machine parts and members of construction are now studied in transparent celluloid models, and their magnitude and location disclosed by the shifting of light waves as viewed by the polariscope.

Without standards and specifications efficient manufacturing is impossible. For them industry is chiefly indebted to testing laboratories throughout the world and to such scientific agencies as the American Society for Testing Materials and the U. S. Bureau of Standards.

AN ADVERTISING AND TRANS- PORTING AGENCY

Once the manufacturer's goods are made he has the problem of finding and reaching the markets. He is, therefore, peculiarly dependent upon means of communication and transportation. The news-print paper, which carries his advertisements, is made at the rate of 800 feet a minute in a web 15 feet wide from the wood pulps of Voelter and Tilghman and printed by presses turning out 48,000 complete newspapers an hour. To that achievement the forester, the metallurgist, the metallographer, the mechanical and electrical engineers, and the chemist have all made essential contributions.

Orders are solicited and received by telegraph and cable, wireless and tele-

phone—all of them the true children of science. There are in New York, under the corner of Broadway and Franklin Street, over 47,000 wires, and in the Bell system 26,000,000 miles of wire, over which 18 billion messages were carried a total of 45 billion miles in 1924. This means far more to the manufacturer than an extraordinary facility of communication. It means that science creates markets. It finds new uses for old materials and supplies new materials to meet new needs. One of its new materials, perm-alloy, an alloy of iron and nickel, permits the continuous "loading" of a transatlantic cable and thereby multiplies the message-carrying capacity of the cable by four.

The life stream of industry flows only as means of transportation permit. Eckel has estimated that in Europe, in 1750, the average cost of transporting a ton of anything must have been well over fifty cents a mile in our present currency. At that time a manufacturer 10 miles away from his main market would have been no better placed in relation to it than one 500 or more miles away today. The use of distant supplies of raw materials was thus restricted and industry in general confined to small units close to good markets. In May, 1921, on the Virginian Railroad, a single engine hauled a train of 111 loaded cars, the total length of the train being 6,100 feet and its weight 15,400 gross tons. To make that record possible metallurgists found the way to make cheap steel; testing laboratories ascertained its properties and defined them in specifications; civil engineers located road beds, calculated curves, and designed bridges; chemists furnished dynamite to blast a way through mountains; and mechanical engineers slowly evolved equipment.

The classic work of Dr. Dudley, when head of the laboratories of the

Pennsylvania system, went far to standardize the railroad practice of the country. His specifications covered rails, soaps, disinfectants, oils for signals and for lubricating, paints, steels in special forms for every use, car wheels, cement, signal cord, and every detail of equipment. He made the transportation of life and property cheaper, safer, and more expeditious by his application of chemistry to the problems of railroad management.

Through the similar co-operation of men trained to the practical application of science the steamship has displaced the sailing vessel as a means of expeditious transport and the motor truck now carries in this country a tonnage comparable in volume to that borne by the railroads.

Goods are made to be sold, and the prosperity of the manufacturer is therefore directly dependent upon the purchasing power of the consumer. This, again, in its ultimate terms, is a function of the producing capacity of the individual, for wealth must be produced before it can be distributed. By vastly increasing the supply of energy available to the worker, by directing its application along lines of maximum efficiency, and through better knowledge and control of the properties of matter, science has so multiplied the per capita output that the value of manufactured products in the United States increased three hundred and sixtyfold between 1812 and 1919 while the population increased only sixteenfold. Such increased production by the individual permits higher wages and creates greater consuming power, and each extension of industry reacts to create new demands. The aluminum process, for example, required great quantities of cryolite and bauxite, for which no broad market previously existed, and stimulated hydroelectric developments, while at the same time making avail-

able to industry a new raw material and a new basis for profitable endeavor.

SIGNIFICANT VALUE OF SCIENCE

With industry already so deeply obligated to science and so obviously dependent upon it for future progress it is a curious anomaly that so large a proportion of manufacturers still are committed to worn-out methods and still are entangled in problems for which solutions have long ago been found. For many of these manufacturers the situation is a dangerous one, for science has a disconcerting way of distributing her gifts to those who recognize their value. The mathematical researches of Abbe transferred the making of optical lenses from England to Germany. The monopoly in sulphur, which Sicily had so long enjoyed, was broken almost overnight by the Frasch process. Of forty-

four American companies engaged a few years ago in the recovery of potash only one remains in business today, and it is that one alone which organized a research staff.

The practical man too often confounds science with mere theory and so sees little place for it in his business. But science, in its industrial applications, is as intensely practical as a market report or a balance sheet. It represents the accumulated experience and organized knowledge concerning the behavior of things, which thousands of the world's best minds have acquired by the incessant questioning of nature for more than a hundred years. As such the manufacturer ignores it at his peril. An enlightened self-interest should lead him to welcome its teachings and generously support research, for research is the mother of industry.

Significant Progress in Research on Photography

By C. E. K. MEES, D.Sc.

Eastman Kodak Company

IN order to make a photograph it is first necessary to obtain materials which are sensitive to light and then to use the materials by exposing them in a camera, treating the exposure in any way necessary, including developing and probably printing, in order to get the finished photograph.

In the early days of the art the photographer himself made the materials which he used. He prepared on glass or paper a sensitive coating which he exposed in the camera and developed it to a negative which was printed on paper coated with another sensitive coating which he had made himself. As photography developed, the preparation of the materials became a commercial operation, and photographers now purchase the materials that they use from firms that manufacture them in large quantities.

Research in photography covers the whole process of photography and falls naturally into two divisions: one dealing with the preparation of the sensitive materials themselves and the other with their use. When the research laboratory of the Eastman Kodak Company was built in 1912 it was seen that of the two divisions into which photography falls each presented one problem of surpassing interest, and in planning the laboratory, arrangements were made to carry on research in both these problems in the hope that a general solution could be found for them. The problem on which most work had been done and on which there was most chance of making progress quickly dealt with the use of photographic materials. It may be briefly stated as follows:

ADVANCES THROUGH RESEARCH

If a photograph is taken of a given subject under given conditions of light intensity and upon a given sensitive material, can we state how nearly the final print will resemble in its light intensities the object that was originally photographed? This problem is the problem which is known as the "theory of tone reproduction."

The other problem deals with the preparation of the sensitive material itself. The negative material used in modern photography consists of a suspension of crystals of silver bromide in gelatin, this being known as the "emulsion." Emulsion-making has developed as an art rather than as a science. Because of the complexity of the physico-chemical processes involved the practice of emulsion-making has far outrun the theory, and no clear physico-chemical theory of emulsion-making exists. The chief problem in connection with this, therefore, was to obtain a physico-chemical theory of emulsion-making, including an explanation of the nature of sensitiveness and of the relation of sensitiveness to the method of preparation of the emulsion.

Work on the first problem, that of tone reproduction, was already far advanced in 1913. The general conditions for the accuracy of tone reproduction in negative materials had already been laid down by Hurter & Driffield in England and by other workers. The photometry of natural subjects such as are photographed had already been carried out. The behavior of printing materials, however, had been studied

only to a very small extent, and although a great deal of work had been done by psychologists on the properties of the eye, which is involved in the subjective phase of the theory of tone reproduction, this had not been applied to the problem itself. Since the nature of this problem was well understood and the groundwork was already clear, the new research laboratory of the Eastman Kodak Company in 1913 started work with enthusiasm to clear up the points that were still involved. The photographic properties of printing papers were investigated and published in a series of photographic papers; at the same time, another series of papers dealt with the sensitiveness of the eye under different conditions of illumination, and these were linked up with the photographic problems. Finally, a general graphic solution of the theory of tone reproduction was obtained, and later a more complete study of printing papers was made, some of the work on which is not yet published. Meanwhile other photographic workers in Germany and England had published a good deal on the same subject, so that at the present time it may reasonably be stated that the problem of tone reproduction is fully solved and that it is possible to give a complete and accurate solution for the reproduction of the light values of any subject on any given photographic material under any given condition of illumination.

An allied group of problems on which investigation has been carried on concurrently is that relating to the formation of the details of images, an investigation of the utmost importance in connection with the photography of spectral lines or of stars, as well as in many of the more popular branches of photography such as motion picture work. In this study attention has been directed to the sharpness of the images

obtained and to the resolving power of the photographic material as well as to a number of minor matters such as the minute displacements which may occur in photographic images and which may affect the accuracy of physical measurements based on photography. The importance of this work is very considerable because at the present time photography is the chief tool in many branches of physics. All modern spectroscopy, practically all branches of astronomy, and nearly all the work that is done with X-rays, with positive rays, with alpha particles, with electrons, depend at some point or other upon photographic measurements and, unless the properties of the photographic materials are accurately known, the results will be to some extent in error. It is not too much to say that there are residual errors, sometimes very small but mostly of moderate proportions, in a great deal of modern physical research arising from the properties of the photographic materials, which it is very difficult to allow for unless adequate special research has been done upon them.

The other great problem of photography, the nature of the sensitiveness of an emulsion and the theory of its preparation, was in 1913 not nearly so advanced as the work on the theory of tone reproduction. It was, indeed, almost *terra incognita*.

Photographic emulsions are made by mixing together solutions of potassium bromide and silver nitrate in the presence of gelatin. In this way there is obtained a precipitate in the gelatin of flat crystals of silver bromide, generally hexagonal or triangular in shape. The properties of the photographic emulsion were known to depend upon the properties of the gelatin and to some extent upon the size of the crystals, although in 1913 very little was known about either the shape or the

character of the crystals. It was soon suggested that the photographic properties were probably connected with the distribution of the different sizes of crystals in the emulsion, and this was confirmed by subsequent research. It is now seen that the theory of emulsion-making can be divided into three sections:

1. The chemistry of gelatin and its effect upon the silver bromide.
2. The relation between the distribution curve of different sizes of crystals and the properties of the photographic material.
3. The production of a given distribution in the emulsion by control of the conditions of precipitation.

Work on the nature of sensitiveness and its relation to the distribution of the crystal sizes has been going on with the greatest activity since about 1920 in photographic laboratories in three countries—in the research laboratory at Rochester, in London, and in Sweden—and a great deal of progress has been made in this field. Therefore, it is probable that before many years have passed an understanding of the relation between the form and distribution of the silver crystals and the photographic properties of the emulsion will be arrived at. At the same time, an organized attack has been made upon the photographic properties of gelatin, and progress is being made in this field also, though the great difficulties of colloid chemistry have made the work quite slow.

A study is now being undertaken on the conditions of precipitation in relation to the dispersion of the grains obtained, and after continued work for a number of years more we may probably expect to obtain a general solution of the theory of emulsion-making and

to place that intricate subject on a definite scientific basis.

UNIVERSAL NEED FOR RESEARCHES

It might seem at first as if such researches as those which have been mentioned, dealing with the fundamental problems of photography, are far removed from manufacturing questions, but this is by no means the case. It is, indeed, impossible for the fundamental properties of a manufactured product and the conditions under which it is used not to have a very close relation to the problems which arise in manufacture. In scientific research undertaken in connection with industry it is most important that research work should be as fundamental as possible. There is always a temptation to attempt superficial investigation of matters on which problems are arising at the moment, but it is almost invariably the rule that the more deeply a matter is investigated the more use the investigation will eventually be in its practical application. It would be easy to give examples of works problems which have been solved by a research laboratory and which have been of immediate value to the manufacturing departments. Every research laboratory must of necessity carry on a great deal of what may be described as service work, and the photographic industry is no exception in this field. Service work is of the utmost importance. It must be done faithfully and quickly with an eye to the practical result and to assisting the department that needs the assistance with the least possible delay and cost.

But the ultimate returns from research to industry will come not from these immediate services, important as they are, but from fundamental investigations of the type with which this brief essay is concerned.

Significant Progress in Research on Fuels¹

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DEFINITION, ORIGIN AND CLASSIFICATION OF FUELS

THE term "fuel" includes all combustible substances which may be burned in contact with air in such a manner as to render the heat evolved capable of being applied to industrial or domestic purposes. Fuels are divided into the following classes:

1. Solid fuels:

- a. Natural fuels—
Coal, lignite, peat and wood.
- b. Carbonized fuels—
Coke and charcoal.
- c. Processed or patent fuels—
Briquets.

2. Liquid fuels:

- a. Natural oils—
Petroleum and petroleum products.
- b. Oils from carbonization of solid fuels and oil shales—
Coal tar, shale oil, benzol, and their products.
- c. Synthetic liquid fuels made from gases—
Alcohols, aldehydes, benzol, etc.

3. Gaseous fuels:

- a. Natural gas.
- b. Gases from carbonization of solid fuels—
Illuminating gas, coke oven gas.
- c. Gases from partial combustion of solid and liquid fuels—
Producer gas, blast-furnace gas, water gas, carburetted water gas, oil gas.

Wood, straw, and other vegetable matter of current growth are only of minor

and local importance. The mineral fuels—coal, petroleum and natural gas—which have been stored in the earth in past geologic eras comprise the important fuels of the present age.

Research has definitely proved that all coal is derived from vegetable material laid down in beds analogous to the peat deposits of today, in undrained basins similar to the Dismal Swamp of Virginia, the Everglades of Florida, and the peat bogs of Wisconsin, but on a much larger scale. Meanwhile, the level of these areas was slowly subsiding, the plant growth keeping pace with the subsidence for a long period, until eventually the depth of water became too great for this growth to continue, and the deposit became covered with silt which formed the roof shales of the present-day coal beds. The peat remains of the biochemical stage of coal formation were gradually compressed by the superincumbent load of sediments, and were finally deprived of much of their water. As a natural consequence of dehydration the peat hardened and was converted into coal of various ranks by pressure of the superincumbent rock, augmented by earth thrusts in some cases, and perhaps by temperature although not necessarily high temperatures.

Petroleum and natural gas may also be of vegetable origin, although direct proof of origin cannot be obtained as in coal. It is possible that these fuels were formed from deposits of animal remains or from chemical reactions of compounds in the earth. The present article will be confined to coal, lignite and peat, together with their solid, liquid and gaseous products.

¹ Published by permission of the Director, U. S. Bureau of Mines.

CONSERVATION OF FUEL RESOURCES NECESSARY

Fuel is essential to our modern industrial civilization. A continuation of our present highly-developed method of living cannot be conceived after the mineral fuel resources of the earth become exhausted. Therefore, in the interest of posterity we should husband the bountiful but definitely limited fuel reserves in the earth. Prodigious waste of this irreplaceable resource must not be countenanced. On the other hand, research on more economical utilization and the prevention of waste should be encouraged by every possible private and public means.

Let us take stock, for a moment, of the world's fuel resources. It is estimated that the available reserves of anthracite and bituminous coal are 4,500 billion tons, or equivalent to 3,600 times the coal consumption for 1916. Petroleum, which is so widely used at present, is a very limited resource as compared to coal, and will probably be exhausted in a hundred years—perhaps 30 years will see the end of petroleum in the United States. Natural gas is approaching exhaustion in even less time. M. R. Campbell, of the U. S. Geological Survey, estimates 2,500 billion tons of available coal, not including lignite, in the United States which, at the present rate of consumption, should last 4,000 to 4,500 years. Another important factor in the life of our coal resources is the loss in mining. In its report to the U. S. Coal Commission in 1923, the U. S. Bureau of Mines stated that in the ten Eastern states producing 90 per cent of our bituminous coal, the average loss in mining is 35 per cent, of which 20 per cent can be avoided by proper methods. However, the high-grade and easily mined coals will last only 100 to 200 years. It is therefore of im-

mediate importance to conserve these good coals by reduction of mining wastes and heat losses in their utilization. In the near future research must also discover economical methods for mining thin and deep beds and suitable processes for using the low-grade coals and lignite.

CLASSIFICATION OF FUEL RESEARCH

Broadly speaking, the object of all fuel research is either to eliminate waste and increase efficiency in the mining, preparation and utilization of fuels, or to convert the raw fuel by treatment or processing into a more convenient or effective form for use with, in many cases, the recovery of valuable by-products for other purposes, as for example, the conversion of coal into coke and gas with the recovery of ammonia for fertilizers. More specifically, fuel research may be classified under mining, preparation, storage and utilization, the last mentioned including the major subdivisions of combustion, carbonization, complete gasification, briquetting and synthetic fuels.

Research on the constitution and origin of coal is not only of great academic interest, but also of fundamental importance in the entire field of fuel technology. Progress in this subject will be given first consideration in order that the reader may better understand its relationship to other fuel problems.

ORIGIN AND CONSTITUTION OF COAL

One of the first consistent and correct theories for the origin of coal was published by Franz von Beroldingen² in 1778. He believed that peat deposits became covered with earth and

² Beroldingen, Franz von, *Beobachtungen, Zweifel, und Fragen, die Mineralogie überhaupt, und insbesondere ein natürliches Mineral System betreffend*, first edition, 1778. Second edition, 1792, Vol. 1.

rock, thus compressing and preserving the decaying vegetable matter and finally producing brown coal, lignite, bituminous coal, or anthracite, depending upon the pressure and geologic age of the bed.

In 1831 Henry Witham³ in England succeeded in making thin sections of certain of the less brittle and softer coals, which on examination under the microscope by transmitted light revealed some plant structure. Subsequent workers with improved apparatus and technique identified more plant structures in other coals, but no comprehensive study from the paleobotanical point of view was undertaken until after the beginning of the 20th century, when Reinhardt Thiessen⁴ and E. C. Jeffrey⁵ in America, and Marie C. Stopes⁶ in England began their investigations. Thiessen, working in the laboratories of the U. S. Bureau of Mines, developed a superior technique for grinding and mounting thin sections whereby he rendered visible not only the spores, cuticles, pollen grains and plant structures seen by other investigators, but also showed very distinctly the woody cell structure in the bright, glossy bands of bituminous coal which were heretofore considered structureless. So detailed were these thin sections that it was possible to identify and correlate coal beds by the appearance of the spores as revealed in microscopic examination. In one bed Thiessen was able to identify

similar spores taken from points 100 miles apart.

Within the last two years, Clarence H. Seyler⁷ in England and H. G. Turner⁸ in America have shown similar plant structure in anthracite by examining polished surfaces which were etched by heat or by chemical oxidizing agents, thus confirming the usual view of the common origin of anthracite and bituminous coal.

Chemical Research on the Constitution of Coal

The coal chemist of the 19th century had a much simpler conception of coal than we have today. To him it was a mineral composed essentially of carbon, hydrogen, oxygen, nitrogen, sulphur, ash and water, in various proportions. His studies on the constitution of coal were directed along the conventional lines of proximate and ultimate chemical analysis, and making deductions from these data without any real appreciation of the fact that coal is a conglomerate of various chemical compounds, including many of the most complex structures known to organic chemistry.

The view of the modern coal chemist is well expressed by Franz Fischer,⁹ who says that while proximate and ultimate analyses are important both from the scientific and technical point of view, they tell the chemist no more concerning the number and kinds of chemical compounds that constitute coal than the reader of a book would learn of its contents if told that the

³ Witham, Henry. On the internal structure of fossil vegetables found in the carboniferous and volitic deposits of Great Britain, 1833.

⁴ White, David and Thiessen, Reinhardt, *The Origin of Coal*, Bull. 38, U. S. Bureau of Mines (1913).

⁵ Jeffrey, Edward C., "The Nature of Some Supposed Algal Coals," *Proc. Am. Acad. of Arts and Sci.*, vol. 46, 1910, pp. 273-290. The Mode of Origin of Coal, *Journ. Geol.*, vol. 23, pp. 218-230.

⁶ Stopes, Marie C., and Wheeler, R. V., *Constitution of Coal*, H. M. Stationery Office, London, 1918.

⁷ Seyler, Clarence A., "The Microstructure of Coal," *Fuel in Science and Practice*, vol. IV, 1925, pp. 56-66.

⁸ Turner, H. G., and Randall, H. R., "A Preliminary Report on the Microscopy of Anthracite Coal," *Journ. Geol.*, vol. 31, 1923, p. 306.

⁹ Fischer, Franz, *Über den Stand der Kohlenforschung Schriften der Brennkrafttechnischen Gesellschaft, E. V.*, Nr. 1, Wilhelm-Knapp, Halle (Saale), 1919, p. 5.

printed contents consisted of 15 per cent of the letter "e," 5 per cent of the letter "n," 1 per cent of the letter "g," 4 per cent of the letter "b," etc. As the reader of the book must have the grouping of letters into words, and words into sentences, so the chemist must have the grouping of atoms into molecules and the proportion of each molecular compound in the coal aggregate before he acquired an adequate knowledge of the constitution of coal. Modern investigators¹⁰ are laying the foundation of a new chemistry of coal based on the biochemistry of plants and the chemical changes involved in processes of fermentation and decay. Since coal was formed from plant matter, and since plant chemistry is better known than coal chemistry, it is most logical to start with the chemistry of plant constituents and of the known products obtained under the various possible modes of decomposition under peat- and coal-forming conditions. American investigators, in particular White and Thiessen, are attacking the problem by this method. From the point of view of paleobotany and biochemistry they are endeavoring to trace the original plant constituents through the successive geologic stages in coal formation, as exemplified in the coals of different ranks from peat to anthracite.

In England, Professor R. V. Wheeler and his co-workers in the University of Sheffield are intensively engaged in

¹⁰ White, David, and Thiessen, R., Bull. 38, U. S. Bureau of Mines, 1914.

Stopes, Marie C., and Wheeler, R. V., Monograph on Constitution of Coal, Dept. of Sci. and Ind. Research, London (1918), revised in *Fuel in Science and Practice*, 1924 issues.

Thiessen, R., "Structure in Paleozoic Bituminous Coal," Bull. 117, U. S. Bureau of Mines (1920).

Fischer, F., and Schrader, H., *Entstehung und Chemische Struktur der Kohle*, Kaiser-Wilhelm Institut für Kohlenforschung in Mülheim-Ruhr. Verlag W. Girardet, Essen, 1922.

separating individual constituents or similar groups of constituents in coal and comparing their properties with similar constituents of the plants of today.

In Germany, Franz Fischer and associates at the Coal Research Institute at Mülheim-Ruhr are vigorously attacking the problems of the constitution of bituminous and brown coal by chemical methods of extraction with solvents, reaction with various reagents, decomposition by heat and pressure, and correlation of these results with a study of the biochemistry of the two principal plant constituents, lignin and cellulose.

These are the leaders of research on the constitution of coal who are laying the foundation for our modern coal chemistry which is necessary to solve the fuel problem of the present industrial age.

RESEARCH IN MINING

Safety research in coal mining has accomplished much to combat the dangers of a naturally hazardous occupation. Coal dust is highly flammable and explosive when mixed with air—that is, as a dust cloud; flammable gas is given off from the coal beds; flame from explosives, open or exposed lights, and electric arcs may ignite the gas or dust, causing tremendous explosions with much loss of life; mine fires create poisonous and asphyxiating gases; falls of roof, if not properly timbered, may maim or kill the careless worker—in fact, half of our fatalities are from falls of roof. Let us see what science and research have done to combat these hazards:

Davy studied the composition of firedamp and devised the well known gauze-protected flame safety-lamp early in the 19th century; later, European investigators proved that the long flame from blown-out shots of black

powder would ignite firedamp (methane-air mixture) and coal dust, but that explosives could be made and used which had such a short, quick flame that they would not cause ignition; and only within the last decade the U. S. Bureau of Mines and the Mines Experimental Station in England have shown how disastrous coal-dust explosions can be prevented by spraying inert stone dust on the floor, sides and roof of the mine.

Organized mining research is now an accepted institution of proved value. In England the Mines Welfare Fund (an assessment of tonnage mined) provides a large sum of money annually for scientific research on the prevention of explosions and fires in mines. The money is expended under the direction of the Safety in Mines Research Board, a body appointed by the Minister of Mines. Experimental stations and laboratories are maintained at Eskmeals and Sheffield. France has a similar mine safety research station at Montlucon, supported jointly by the coal operators and the Government. In the United States the Federal Bureau of Mines, organized in 1910, at Pittsburgh, has established extensive research laboratories and an actual underground experimental coal mine for research on safety and efficiency in both mining and utilization of coal. If the recommendations of these research organizations were followed in all coal mines there would be very few, if any, mine explosions.

Efficiency research has naturally lagged behind safety research. At the present time, through economic pressure, there is much research in America on machines for cutting, loading and conveying coal, and obtaining greater efficiency in the use of explosives. For example, during 1924 a six months investigation on methods of blasting coal in a mine in western Pennsylvania re-

sulted in increasing the percentage of lump coal from 64 to 71 per cent and in decreasing the amount of explosives used by 31 per cent.

RESEARCH ON PREPARATION OF COAL

In its simplest form the preparation of coal consists of screening the material into various sizes and picking out the large and conspicuous pieces of slate. Ash and sulphur are objectionable impurities in coal used for the manufacture of metallurgical coke, as they add to the cost of smelting and affect the iron and steel. The famous Connellsville coal of Pennsylvania and certain other coals in Kentucky and West Virginia are naturally so low in sulphur and ash that they are used directly without purification for the manufacture of metallurgical coke. But these pure coals are approaching depletion so that in the future washing processes will be applied to low-grade coals to reduce the impurities sufficiently for use in making coke. It is probable that even coal used for steaming and heating purposes will be washed to save the high cost of transporting and handling the surplus ash. At the present time about 5 per cent of our bituminous coal is washed.

Much ingenuity and inventive ability have been given to the design of various types of jigs and shaking tables by which the coal and impurities are separated by differences in specific gravity. All of these processes use water as the medium in which the coal is suspended, but water has certain objectionable features, especially in treating fine coal, in that 10 to 15 per cent of moisture remains in this coal. Research is therefore being carried on with apparatus using air as a means of separation. In Europe, where coal is more valuable than in America, froth flotation plants have been installed for recovering the very fine coal dust that

remains suspended in the waste washery water. By adding minute quantities of certain oils to the water the fine coal can be collected and skimmed off as froth; the heavy impurities remain in the water. In one process a large quantity of oil—up to 20 per cent of the weight of the coal—is added and the mixture agitated. The particles of coal and oil agglomerate to a plastic mass called amalgam. The impurities remain suspended in the water. One of these plants in Toledo is pressing this coal-oil amalgam into briquets about 4 by 8 by 15 inches and wrapping them in paper with an automatic machine, thus providing a clean, high-class domestic fuel. The amalgam fuel is made from fine slack which is available at low prices at the mines.

In the anthracite region another process cleans coal by agitating it in a mixture of sand and water of such a gravity as to float the coal and allow the impurities to sink. The ash content is thus reduced from 40 to 10 per cent.

The needless economic waste of transporting slate, shale and other rock mixed with coal from the mines to the market is becoming appreciated. Large consumers are using scientific methods of analyzing and determining the heat units in the coal they purchase. Under present highly competitive conditions, the operator who does not carefully control his product fails to find a purchaser for his output and many mines have been closed through this cause.

RESEARCH ON STORAGE OF COAL

The tendency of coal to react slowly with oxygen of the air at ordinary temperatures and under favorable conditions to heat and ignite spontaneously makes it difficult to store coal safely in large quantities. Fundamental chemical research on the constitution of coal

is revealing some of the causes of spontaneous heating. Chemists are obtaining some idea of the particular constituents that are most reactive with oxygen. It is now definitely known that the coal substance itself heats spontaneously and that the sulphur content may be a contributing but not the only cause. Research on spontaneous combustion has shown that coal can be stored indefinitely without danger of combustion if it can be protected from the air as, for example, storage under water. In air storage the danger can be minimized by limiting the height of the piles to about 15 feet so as to permit the heat to escape.

RESEARCH ON UTILIZATION OF FUELS

Research on the better utilization of mineral fuel probably began with its discovery. No doubt the first Roman who tried to burn coal in England objected to the smoke and odor. It is recorded that King Edward I in 1306 prohibited the use of coal as a fuel in London because of the heavy smoke and pungent odors. Likewise the Parisians as late as 1714 did not permit coal to be used in their city. However, the rapidly disappearing forests soon forced the use of coal, and from that day to this British investigators have been trying to convert it into some form of fuel that may be burned in their open grates, radiating a cheerful glow but emitting no obnoxious smoke to the neighborhood. Seventy per cent of the bituminous coal mined in the United States is used for steam raising either in stationary boilers or in railroad locomotives. Obviously the fuel economy in steam raising is of first importance.

RESEARCH ON COMBUSTION

In reviewing progress in this field it is gratifying to note the tremendous advances in the fuel economy of the large

central power stations of the United States. The invention and general introduction of automatic stokers has eliminated smoke to a large degree and has improved the uniformity of combustion. A few decades ago the transfer of two-thirds of the heat in coal to the steam going to the engine was considered good practice, even for large power plants. The present efficiency of over 90 per cent in certain modern steam plants is unquestionably due to the intensive research on combustion and steam generation that has taken place in recent years.

Intensive fuel research in America had its inception in the establishment of the U. S. Fuel Testing Plant at the Louisiana Purchase Exposition in 1903. Credit must be given to the vision of Dr. Joseph Austin Holmes, the first Director of the U. S. Bureau of Mines, subsequently established, who appreciated the great need of fuel conservation in mining and utilization. At the World's Fair, Professor Holmes assembled a group of investigators who began a survey of the fuel resources of the United States. They analyzed, determined the heating value, and tested carload samples of coal and lignite from all parts of the country, including research on combustion, coal washing, briquetting and gasification. This work is continued today at the Pittsburgh Experiment Station of the Bureau of Mines where 10,000 samples of coal and lignite are analyzed annually, and where research is conducted on the mechanism of combustion in boiler furnaces, ceramic kilns, metallurgical furnaces, and house-heating stoves with the object of increasing efficiency and reducing smoke.

Undoubtedly the most significant modern achievement of fuel research is the successful use of pulverized coal in large power plant boilers. The burning of coal in the pulverized form has many

of the advantages of burning gas. It permits of great flexibility in operation and gives a remarkably high efficiency. Over 90 per cent has been obtained in regular operation.

The idea of using powdered coal is over 100 years old, but it passed the experimental stage only 5 years ago. The present rapid growth is due to organized and deliberate research by engineers in the industry with the aid of scientists from the Bureau of Mines. Recently a large central power plant with automatic stokers, steam economizers, and air preheaters for recovering every possible heat unit from the waste gases has also attained over 90 per cent efficiency. It is an interesting race between stoker-fired and pulverized-coal power plants in which both contestants are taking advantage of all the discoveries of research in combustion, heat transmission, ceramics and metallurgy.

CARBONIZATION RESEARCH

Carbonization of coal is essentially the conversion of low-grade fuel to the higher form values of coke, gas and tar. By-products of economic value such as ammonia, naphthalene, etc., may also be recovered. Carbonization may be carried on primarily for the production of metallurgical coke or manufactured gas. A third form of carbonization in which the principal object is the maximum production of liquid fuel is known as low-temperature carbonization. This method is still in the experimental stage.

The field of coal carbonization has abounded with opportunities for research from the days of Murdock, who made the first practical application of gas lighting in 1792, to the present time. The industry has developed along two parallel lines—the manufacture of coke on the one hand, in which the gas and tar were allowed to

escape into the atmosphere for many years; and the manufacture of gas on the other hand, in which the process was so conducted as to obtain the maximum yield of a high candle power gas. The coke was considered a necessary evil and was disposed of as best it could. Today these two parallel methods of carbonization development are gradually converging. The discovery of the Welsbach gas mantle permitted the use of uncarburetted coke-oven gas for lighting purposes. The increasing demand for coke for domestic fuel favored the coke-oven type of equipment; and finally the development of the by-product coke oven with its lower labor costs and larger units including recovery of all the gas, tar and ammonia made this process more economical for large installations. It is evident therefore that the technology and economics of gas and coke manufacture are approaching near enough to each other so that a compromise plant and process can be used to serve both needs. The same plant can furnish manufactured gas for city use and provide coke for foundries, blast furnaces and domestic furnaces.

By-Product Coking

The wasteful beehive coke oven is fast disappearing in America; owing to the low investment and capital cost the present installations will probably remain for a number of years to take care of peak loads in times of great industrial activity. In times of depression the beehive plant is the first to shut down. It was not many years ago that blast-furnace superintendents utterly condemned the coke made in by-product ovens. It lacked the beautiful silvery luster and the hardness and density of beehive oven. Now the situation is reversed; investigation has shown that the more uniform coke made in by-product ovens is better for

blast-furnaces, and 70 to 80 per cent of our coke is made by this process.

Much credit is due to manufacturers of by-product ovens for supporting well-equipped research laboratories manned with able staffs of scientists. Results of this research have put the United States far ahead of any other country in by-product coke-oven design and operation. The substitution of silica brick in place of fireclay has permitted the use of higher temperatures whereby the coking time has been greatly shortened—in a comparatively new oven to 11 hours. The introduction of narrower chambers has further shortened the time and has made it possible to coke coals and mixtures of coal heretofore considered non-coking. New methods have been developed for the removal of sulphur from the gas in case it is desired to use it for domestic purposes. The light oils are becoming an appreciable factor in the motor-fuel supply of cities in the coking districts. The tar forms an excellent substitute for fuel oil in heating open-hearth furnaces in the steel plants. Ammonia and raw materials for dyes, explosives, etc., are now recovered in all by-product coking plants. No fuel industry has benefited so much by organized research, and much more may be expected in the future because competition is very keen in this industry.

Gas Manufacture

There has not been the same relatively rapid progress in gas manufacture that has characterized the by-product coke industry in the last decade—in fact, the gas-manufacturing industry today is borrowing many new developments from the more aggressive by-product coke industry. In the early days manufactured gas was made principally for illuminating purposes, and was burned in ordinary fish-tail burners. Certain unsaturated con-

stituents of high molecular weight were essential to give it sufficient illuminating value. These could only be obtained by distilling the coal and leaving the light oils in the gas. The invention of the Welsbach mantle did away with the necessity of a candle-power standard, although it required many years to eliminate this requirement from city ordinances. The candle-power standard was followed by a heat unit or B.t.u. standard. This figure was naturally set at the average existing value of the high candle-power gas then in use.

Subsequently, research in governmental and in industrial laboratories showed that the value of a gas was directly proportional to its heating power or B.t.u. content, and in many cases the over-all fuel efficiency of using coal in the form of gas would be greater if converted into lower B.t.u. gas such as results from complete gasification of fuels. It was not until the stress of the war period (1914-1919) that the regulations for the sale of gas were made flexible enough to allow it to be sold on a heat-unit basis. This is now done in Great Britain where gas is sold by the "therm," which is equal to 100,000 B.t.u.

The inroads on gas lighting by electric lighting have been more than compensated by industrial consumption of manufactured gas; much of this consumption is stimulated by organized research conducted by the gas companies themselves on gas-heating processes. Most important of the new developments in the manufactured gas industry during the last two decades have been the development of continuously and intermittently charged vertical retorts and the development of an abbreviated form of the by-product coke oven. The advantages of these newer forms of ovens are in the production of a denser coke approaching

that of metallurgical coke in quality, and in lower operating costs.

COMPLETE GASIFICATION

The complete conversion of coal into gas either in one or two stages is called "complete gasification." Producer gas and water gas have been made for many years from coke or anthracite by blowing air or steam and air through the hot fuel bed. Such gases are of low heating value; producer gas has from 120 to 150 B.t.u. and water gas from 270 to 300 B.t.u. per cubic foot. Low installation cost and fairly good thermal efficiency favor this form of gas fuel where it can be used directly without long transportation. Important recent advances in this field have been the complete gasification of bituminous coal, whereby the coal is converted into coke by the sensible heat of the hot producer gas in the top of the retort and whereby the resultant hot coke is converted to producer gas or water gas in the lower zone of the apparatus; it is thus possible to recover liquid by-products and ammonia and save the sensible heat of the hot coke which is lost in a two-stage process.

LOW-TEMPERATURE CARBONIZATION

At the beginning of this paper attention was called to the comparatively early exhaustion of the world's petroleum resources. If liquid fuel is to be used in the distant future it must be obtained from solid fuel such as coal, lignite or oil shale, or it must be synthesized from gases produced from coal. During the World War, European countries that had no domestic petroleum supplies were impressed with the need of making a liquid fuel from coal which could be substituted for petroleum in military emergencies. The carbonization of coal at low temperatures (1000° F.) produces approximately twice as much liquid fuel as

high-temperature carbonization. It is also possible in certain of these processes to produce a semi-coke which contains enough residual volatile matter (8 to 15 per cent) to make it easily ignitable and free-burning—an excellent smokeless fuel for use in open grate fires. Therefore in England, where grate fires are the rule, much research has been conducted by public and private interests in attempting to develop low-temperature carbonization processes.

The Fuel Research Station at East Greenwich, England, working under the direction of the Fuel Research Board of the Department of Scientific and Industrial Research, is making a fundamental study of the chemical, thermal and economic factors involved in low-temperature carbonization and is collecting reliable data that are not subject to the bias of experiments undertaken by commercial interests. In Germany, during the World War, rotary retorts similar to those used in the cement industry were devised for carbonizing coal at low temperatures. Several of these were actually put into operation and provided substitutes for fuel oil and lubricants from low-temperature tar. Operating costs, however, were too high for competition with petroleum after the war. Research is being continued in the hope that larger outputs may be obtained with cheaper installations and with utilization of semi-coke as powdered fuel in power plants.

The well-known Carachristi-Peron process of the Ford Motor Company has the same object of burning the fuel in pulverized form after the oils and tar have been extracted. The economics of such processes necessarily hinge upon greatly enhanced prices above the present level for petroleum products. No low-temperature carbonization process has yet reached the point of successful operation at a profit. The

field is still open for investigation. Low-temperature tar has an entirely different composition from high-temperature tar, and its constituents are practically unknown. It is worthless today, but research may show a much greater value tomorrow, and some radical departure in carbonization design may reduce costs to the point where it becomes commercially feasible.

The carbonization of lignite and the distillation of oil shales is unquestionably an important future industry. Even at the present time the states of North and South Dakota, Montana, and the Province of Saskatchewan are interested in obtaining a usable fuel from their local lignite deposits. It would be an economic advantage if the long transportation of high-grade coal to these regions could be avoided. The Canadian Lignite Utilization Board and the U. S. Bureau of Mines have conducted considerable research in the carbonization of lignite and in devising carbonizers of low enough cost to be practicable under present conditions. The Hood-Odell (of Bureau of Mines) carbonizer resulting from this research appears to be at the point of commercial success. The charred residue burns without smoke and the fine material when briquetted is an excellent substitute for anthracite.

SYNTHETIC PROCESSES

Bergius, in Germany, has developed a process for converting coal, or the greater part of it, into liquid fuel. A mixture of pulverized coal and petroleum is heated to a temperature of about 700° F. in an atmosphere of hydrogen gas under a pressure of 200 atmospheres. Under these conditions the greater part of the coal is converted into liquid products which may be separated into approximately one-third each of heavy gasoline, Diesel engine oil, and fuel oil. Another German in-

investigator, Dr. Franz Fischer, has made a liquid fuel which he calls "Synthol," by heating water gas under similar high pressures in the presence of a catalytic material consisting of iron coated with potassium carbonate. Neither of these processes is commercially feasible at the present time, but they illustrate the tremendous possibilities in changing the form value of fuel as a result of scientific research.

CONCLUSION

The World War forced upon every nation a realization of the tremendous importance of fuels in their various forms. It demonstrated the value of scientific research and the need of each nation to provide adequate sources of those particular forms of fuel that were best adapted to modern warfare—namely, petroleum and its products. It stimulated much research along lines which did not promise commercial returns under ordinary conditions, but which promised means of obtaining the necessary forms of fuel when the nations were thrown entirely upon their domestic resources. Every important nation (from the United States with 110,000,000 people to New Zealand with 1,300,000 people) has established, either directly or indirectly, fuel research laboratories for carrying on these important investigations.

The result is evident from a glance at the enormous increase in the literature on this subject. From 30 to 50 important books have appeared within the last five years on coal chemistry, high- and low-temperature carbonization, fuel engineering and combustion, to say nothing of articles in the current technical press. There have also appeared in the last five years the following periodicals devoted entirely to fuels—namely, *Fuel in Science and Practice* in England; *Chaleur et Industrie* in France; *Brennstoff-Chemie* in Germany; and *Fuels and Furnaces and Combustion* in America.

There is every indication that interest in fuel technology will continue to increase in the future. The only drawback is the lag between research and practice. Where direct monetary returns are to be obtained, practice seizes upon the results of research at once, but in the more general field of conservation, in more complete extraction of the coal from the ground, in the adoption of smokeless fuels at a somewhat higher cost, and in the elimination of known unsafe practices in mining, much educational work remains to be done. It is hoped that practice will follow the pioneering line of research in these more altruistic aims much more closely in the future than it has done in the past.

Significant Progress in Research in Metals

By GEORGE L. KELLEY

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RESEARCH devoted to a study of metals is a comparatively new field of investigation. As is usual, the earlier work was chiefly academic. The beginning of research in metal industries is to be found in the works laboratories established for process control, but within recent years many of these laboratories have extended their work to include process investigation and development. A few of the larger companies have established laboratories devoted solely to research. In most instances these are concerned with investigation in many departments of knowledge of which the study of metals is only one. Such laboratories sometimes attain to very great size, numbering more than a hundred research workers and having an annual budget approaching a million dollars. These research men are frequently specialists with extensive training in their own field. Association with men educated in other directions offers manifest advantages in the opportunity for the collaboration of experts in related subjects. Manufacturers of metal products in some instances have developed laboratories engaged in the study of the metal problems peculiar to the given industry. Many of these are operated under conditions sufficiently liberal to permit of the study of fundamental questions of a purely scientific character, but most have a more utilitarian point of view. However, confidence in the value of work which does not promise immediately useful results is increasing. There is less tendency to leave such problems to the universities. Along with this is a growing disposition to employ highly trained men

of the research type in an effort to solve troublesome plant problems.

The application of research to industry has not always yielded satisfactory results. Success, or lack of it, has much the same make-up here as elsewhere. The elements seem to be men, methods and opportunity. Research men are not necessarily men of genius, but unless they have a certain point of view, they are not productive investigators. The field in which men are called upon to work may be one in which the development of methods has been tardy. Without these, progress is slow at best. Opportunity may be a matter of facilities, or it may be merely a question of moral support.

Perhaps it is because the nature of research is not generally understood that the term is so often used as a sort of charm. Sometimes it is the researcher himself who trades on the good repute of the work. Again it is an enterprising advertiser who calls attention to the fact that his product is the result of research. In both cases there may be, and often is, real merit behind the claims. Too frequent iteration of these, however, is liable to lead to extensive discount. If the tendency to point to research as a mysterious process of thought out of which great things have come, and from which almost anything may be expected, should give way to a more conservative attitude, the condition would not be fraught with such unpleasant possibilities.

The Crystalline Structure of Metals

This aspect of the study of metals has claimed attention since the advent

of metallography. Jeffries¹ and his associates have extended the work begun by Sauveur and Stead on the effect of strain upon crystal growth during annealing. These investigators have expressed in general terms the conditions governing crystal growth in metals in which are shown the effects of strain gradient, temperature gradient and grain size contrast, as well as the usual effects of time and temperature. The inhibition or prevention of grain growth in metals has found practical application in the introduction of thorium into the tungsten filaments used in incandescent lamps. The study of the conditions of crystal or grain growth has been of value in the control of grain size in commercial annealing operations on metals.

Recently, much interest has been shown in the properties of metals in the form of large single crystals as contrasted with those of the usual crystal aggregates. Carpenter and Elam² have succeeded in converting test pieces of aluminum four inches by one inch by one eighth inch into single crystals. This was accomplished by heating aluminum which had previously been subjected to a mild overstrain, slowly increasing the temperature during several days. The product was found to be remarkably malleable, remaining quite ductile after 93 per cent reduction.

The elongation in one instance was 86 per cent in three inches. Mark, Polyani and Schmid, in Germany, prepared single crystals of zinc in the form of wires 2 mm. in diameter. On those occasions in which the plane of easiest slip made an angle of approximately 45 degrees with the axis of the wire, remarkable ductility was exhibited where they were broken in tension. At room temperature, an elongation of 600 per

cent was obtained and at 205° C. the elongation amounted to 1,700 per cent. This is greater elongation than has previously been obtained with any metal. The very brittle bismuth, in the form of single crystal wires under the same favorable conditions, gave an elongation of 300 per cent at 200° C. Mark and Polyani³ found 800 per cent elongation in a single crystal of tin. The tensile strength of such single crystal metals is lower than that of metals made up of an aggregate of crystals. Carpenter and Elam found the tensile strength of their aluminum to vary between 6,270 and 9,180 pounds per square inch, while the strength of ordinary aluminum would be 1,000 pounds greater than the stronger of these. W. P. Davey, of the General Electric Company at Schenectady, using the method of P. W. Bridgeman, prepared large single crystals of copper. He was able by this means to prepare crystals seven-eighths of an inch in diameter and six inches long. A crystal of the size of a lead pencil, if given a jerking motion, bends like a piece of soft wax. A larger crystal can be bent with the pressure of a finger, but cannot be straightened again with both hands. These crystals exhibited an electrical conductivity 13 per cent greater than ordinary pure copper. After hammering, swaging and annealing to produce the structure of ordinary copper only ordinary conductivity was found.

Theories of the hardening of metals are still in process of formulation. The theory of Beilby that hardness in steel is due to the formation of amorphous metal on slip planes is not acceptable to Rosenhain,⁴ on the ground that the amount of deformation during quenching is not sufficient to bring about the structural disorganization

¹ *The Science of Metals*, Jeffries and Archer.

² *Proc. Royal Soc. Series A*, Vol. 100, No. A, 704, p. 329, Dec., 1921.

³ *Z. Physik*, 1923, 18, 75-96.

⁴ *Introduction to Physical Metallurgy*, Rosenhain, p. 181.

which must precede the formation of partially amorphous metal. He offers the alternative explanation that the amorphous metal appears in films about the growing crystals of δ -iron or α -iron. In accordance with his theory, the hardness of the amorphous layer is increased by the presence of carbide in a high state of concentration rejected to the boundaries as the γ -iron or γ -iron undergoes change to δ -iron or α -iron. In a subsequent paper Rosenhain expands and somewhat modifies the above theory.

In the later view it is held that cold work hardens not only by producing amorphous metal on the glide planes which is attended by the fragmentation of large crystals, but also by the roughening of glide planes and the resistance encountered at interfaces when a new orientation is met. These all serve to add to this effect. The hardness which is produced by quenching he conceives as due to the finely divided, highly dispersed hard particles. This interrupts the crystalline lattice of the mother solution and results in its partial amorphitization. Jeffries and Archer⁵ in their slip interference theory appear to accept the theory of Rosenhain and Ewing and the "obstruction principle" of Howe,⁶ but both are extended. They state that every known method of hardening can be referred to slip interference. The hardness and strength of amorphous metal are due to the absence of the planes of weakness characteristic of crystals. The hardness of quenched steel is due to the "keying" effect of hard cementite (iron carbide) particles on slip planes of the grains of α -iron. On quenching, cementite is precipitated rapidly from the solution in which it exists at the

higher temperature. The large number of fine hard cementite particles is believed to offer effective resistance to slip and to be responsible for the manifestations of hardness and strength.

Modifications of this theory are used to explain hardness in other metals. That there is high cohesion between iron atoms is apparent from the strength and hardness of cold worked iron, but cold work does not develop the maximum strength of which the metal is potentially capable. This is shown by the fact that hard drawn wires having four times the strength of pure iron show a considerable reduction of area when broken in tension. This evidence that considerable movement occurs on the slip plane likewise indicates that slip interference is not completely effective. The hardening of some of the light aluminum alloys is explained as due to the presence of a finely divided copper-aluminum precipitate. It is noted, too, that the precipitate so formed may be either too fine or too coarse to produce the maximum degree of hardness.

Colloidal Theory Applied to Metallurgy

Benedicks⁷ in 1910 suggested that the carbide in troostite—a constituent of semi-hard steel—is present as a colloidal suspension. Numerous other attempts have been made to explain certain of the phenomena of metals by analogy with colloids. The experimental difficulties, however, are such that the idea is still in the speculative stage. Alexander⁸ believes that the so-called amorphous phase may not be truly amorphous, but that it is instead made up in part, if not entirely, of ultramicroscopic crystals. He suggests that the expressions amorphous phase

⁷ *Zeitsch f. Chem. U. Industrie der Kolloide*, 1910, p. 290.

⁸ *Transactions of the American Institute of Mining and Metallurgical Engineers*, 1921, 64, 524-544.

⁵ *The Science of Metals*, Jeffries and Archer, p. 403 et seq.

⁶ *The Metallography of Steel and Cast Iron*, H. M. Howe.

and amorphous theory might be replaced by the expressions colloidal phase and colloidal theory. Imhausen⁹ points out that colloids differ from non-colloidal systems in the size of the particles and degree of dispersion. Some analogy is found in metals in the differences in properties which attend a difference in grain size. The properties of hardened and tempered steel analogously might be explained as due to differences in the degree of dispersion of the carbide. Mathewson¹⁰ says:

The paper by Mathewson and Phillips, in 1916, stimulated a valuable and rather long discussion of the subject of recrystallization by Jeffries, Howe and others, and the trend since that time, while productive of a mass of data, has not, so far as I can discern, brought us much beyond the speculative stage in appreciating the exact causes of recrystallization or following its very early stages of operation.

One cannot escape the feeling that our knowledge of the causes of hardness is in a similar indefinite state. Further progress will doubtless come through the development of new methods of attack.

High Power Metallography

Papers by Francis F. Lucas,¹¹ of the Bell System Laboratory, disclose remarkable results obtained by the magnification of metals to 5,250 diameters. In one of the photographs exhibited there, the lamellar structure in a single martensite needle is very clearly shown. This method is so recent in origin that there has not been opportunity to test its fruitfulness as applied to metallographic research.

Crystal Structures

The most promising new method available for the investigation of metals

is that of X-ray diffraction. By this method it has been possible to learn much of the arrangement of atoms within the crystal. Both metals and compounds have been studied. The instrument used is the X-ray spectro-scope.¹² In the crystal the atoms are arranged in regular planes. These planes act in a manner analogous to the lines on a diffraction grating. The procedure consists in effect in measuring the distance between these planes. Crystals are, of course, three dimensional, and accordingly, to gain information necessary for the construction of a crystal model, it is necessary to measure three or more sets of planes in different directions. Evidence so obtained, in conjunction with the information supplied by crystallography, makes it possible in many instances to construct crystal models which show the distribution of the atoms in the resulting space lattice. As a direct result of the measurements, the distance between planes of atoms is obtained and, in addition, some less direct evidence of the size and shape of the atoms. At least four variations on the method are employed, selection of the method sometimes being made on the basis of the characteristics of the material being examined and again from personal preference alone. The list of workers in the field is now large, but special credit is due Laue,¹³ Bragg & Bragg,¹⁴ Hull¹⁵ and Debeye¹⁶ and Scherrer. Jeffries and Bain¹⁷ as well as other investigators have used this method in the study of metals.

We now know with a fair degree of definiteness concerning most of the

¹² R. W. G. Wyckoff, *J. Franklin Inst.* Vol. 195, 183-1923.

¹³ *Ann. d. Physik*, 42, 989 (1913).

¹⁴ *X-rays and Crystal Structure*, W. H. and W. L. Bragg. G. Bell & Sons: London.

¹⁵ *J. Franklin Inst.*, 1922, 193, p. 189.

¹⁶ *Physik Z.*, 17, 277-1916.

¹⁷ *Science of Metals*, Jeffries and Archer, p. 61.

⁹ *Stahl V. Eisen*, 1921, 41, 1641-1649.

¹⁰ *J. Franklin Institute*, 1925, 199, p. 47.

¹¹ *Bell System Technical Journal*, 1924, 3, 100-144; *Trans. Am. Soc. of Steel Treathers*, 1924, Vol. 6, pp. 669-691.

common metals, the nature of the space lattice, that is, body centered cubic, face centered cubic, etc., in which the metal occurs. It appears, too, that in the case of metallic solid solutions, the crystals of the solid solution are built up on the same space lattice as the solvent metal. When the two metals are very similar, the atoms of the two elements appear mixed indiscriminately in the space lattice. When, however, the difference between the metals is marked, it is probable that two different kinds of solid solutions would appear, each containing both kinds of atoms. Since two metals are never identical, it follows that the introduction of even a similar metal into a space lattice will disturb existing relations. As the metals differ more and as their mutual solubilities become less, the disturbances become greater. This results in increasing hardness. It is in such a manner that Rosenhain¹⁸ explains the hardness of solutions made up of two metals having a limited mutual solubility. In such binary alloys, the hardness is usually greatest at a point where the maximum solubility is reached. Those elements having the lowest solubility have the greatest effect in increasing hardness. Nickel and silicon, which are extensively soluble in iron, have only slight hardening effect, while carbon, with its lower solubility, produces a very notable hardening.

Constitutional Diagrams

Work upon the constitutional diagrams of alloys is less active than formerly. This is in part because the simpler as well as the more interesting combinations have already been developed. It is probably mainly due to the fact that less information has been gained from the diagrams than was ex-

pected. They will, however, be developed in all fields of special interest for of course no work with alloys is complete without such data.

Magnetic Analysis

It is stated by Burrows¹⁹ that for any set of properties in a metal there is one and only one set of magnetic properties. Much interest has been shown in this method of analysis but the number of practical applications remains small. One manufacturer uses it to test certain types of large forgings for internal defects. Another uses it to test case-hardened chain. This method of test offers a marked advantage over most others in that the material tested need not be cut, drilled or even marked in any way. It is on trial in a number of other applications. Further investigations will undoubtedly develop many uses for this method apart from those cases in which the magnetic properties themselves are of interest.

Metallic Cementation

Sirovich and Cartoceti²⁰ have succeeded in bringing about the cementation of copper by manganese through the use of iron-manganese carbon alloys rich in manganese. They also succeeded in cementing copper with aluminum by using an alloy of iron and aluminum containing 60 per cent of aluminum. The temperature in the latter case was 750° C. The authors believe that the mechanism of the process is that of vaporization followed by absorption and diffusion. In another paper,²¹ the same authors report a cementation of copper by manganese, using for this purpose a powdered alloy of chromium and manganese. At a

¹⁹ Proc. A. S. T. M., Vol. XVII, Pt. II, p. 80 (1917).

²⁰ *Gazzetta Chimica Italiana*, 1922, 52 (2), 233-245, 245-249.

²¹ *Gazzetta Chimica Italiana*, 1922, 52 (1), 436-442.

¹⁸ *Metallurgical Chemical and Engineering*, 1921, 25, 243.

depth of .1 mm., the case contained in all instances from 5 to 20 per cent of manganese. No manganese was found at a greater depth than .6 mm.

Special Steels

The interest which formerly attached to the nickel chromium steels is now enjoyed, although in less degree, by the molybdenum steels. These steels contain as alloying elements either molybdenum alone, or molybdenum associated with nickel, chromium and vanadium. In all cases, the characteristics of the new steels are improved over those of the older type to which they correspond except for the addition of molybdenum. With a given tensile strength, there is a slightly increased elongation and reduction of area. The early stainless steels contained approximately 15 per cent of chromium with carbon ranging from .4 to 1.25 per cent. These steels could be hardened and were used largely in the manufacture of stain resisting cutlery. This list has now been extended by the addition of low carbon chromium steels. One variety contains more than ordinary amounts of silicon. While these cannot be hardened, they find many uses where great resistance to stain and corrosion is necessary. The physical properties are equal to those of medium carbon machine steel. It is to be expected that they will play an important part in the manufacture of automobile hardware, automobile fenders, turbine bucket blades and other articles.

Steels for use in the manufacture of permanent magnets have usually contained as the principal alloying element either chromium or tungsten, but the greatest development in this field seems to be a steel produced by Honda and Saito.²³ It contains 35 per cent of cobalt, 7 to 9 per cent of molybdenum or uranium and .5 per cent of carbon.

²³ *Phys. Rev.*, 16-495-500, 1920.

Yensen²⁴ has found that the magnetic permeability of silicon steel can be increased by repeatedly melting *in vacuo*, which removes gases. A high frequency induction furnace is used. Arnold and Elmen²⁵ describe an alloy consisting principally of nickel 80 per cent and iron 20 per cent. This alloy has remarkable magnetic properties when properly heat-treated, to which influence it is very susceptible. Under these conditions, its permeability at small field strengths is many times greater than that of any other known metal. This alloy, and other alloys of similar composition, are called perm-alloy. The discovery of these alloys is expected to revolutionize submarine cable construction and operation.

Tool-cutting Alloys

High speed steel, the chief of these, has undergone no considerable change within recent years. In some instances, cobalt amounting from 2 to 5 per cent has been added to the tungsten, chromium and vanadium normally present, but the advantages have not been outstanding. Haynes' alloys of the Stellite series, consisting of tungsten, molybdenum, chromium and cobalt, continue to supplement the use of high speed steel in special cases. Cooper²⁶ has developed an alloy consisting principally of nickel and zirconium with smaller and possibly unimportant amounts of iron, aluminum and silicon. Although not in itself very hard, it possesses the property of red hardness in remarkable degree.

Light Alloys

Aeroplane and dirigible construction has added greatly to the interest in light alloys. Extensive investigations have

²⁴ *Univ. of Ill. Bulletin* 83 (1915).

²⁵ *J. Franklin Inst.*, 1923, 195, 621-632.

²⁶ *Trans. Amer. Electro Chem. Soc.*, 1923, 43 215-225.

been carried on in many countries. Perhaps the most comprehensive work has been that of the National Physical Laboratory at Teddington under Rosenhain.²⁶ Alloys of the duralumin type, containing about 95 per cent of aluminum with four per cent of copper and one-half per cent each of manganese and magnesium, continue to offer the greatest promise of usefulness. These alloys in the annealed condition have about twice the strength of aluminum. After hardening, the tensile strength is equal to that of low carbon steel with a density of only one-third. They are hardened by quenching in water from about 500° C., but hardening is not noticeable until one hour after quenching and then continues for four days before maximum hardness is attained. The same degree of hardness may be obtained by heating in boiling water 24 hours. In the period before hardening begins, the cold working properties are similar to or even better than those of the annealed metal. Like steel, by cold work, the strength can be raised to about 70,000 pounds per square inch.

Alloys of aluminum, silicon, magnesium and zinc have many properties in common with alloys of the duralumin type. Sometimes copper is present. An alloy consisting chiefly of aluminum and silicon²⁷ (11 per cent) has much higher physical properties than aluminum and is suggested for use in making light metal castings. Alloys containing from 88 to 97 per cent of magnesium²⁸ are also of interest. They are lighter than the aluminum alloys and less strong. The other elements present in these alloys are usually aluminum, zinc, manganese and copper.

²⁶ Eleventh Report to the Alloys Research Committee on some Alloys of Aluminum. Nat. Phys. Lab., Teddington, England, Aug., 1921.

²⁷ *Foundry Trade Jour.*, 1922, 26, 304.

²⁸ *Trans. Am. Soc. for Steel Treating*, 1922, 2, 607-615.

Heat Resisting Alloys

Steels containing a high percentage of chromium show much less tendency to scale than do steels of ordinary composition. Brophy²⁹ reports an alloy of iron, nickel and aluminum which is proof against oxidation at 1300° C. An alloy of nickel chromium containing about 80 per cent of nickel is the most widely used. Besides its resistance to scale formation while hot, it has the further advantage of having somewhat higher physical properties at high temperatures than other materials of similar low cost. This has led to its extensive use as a resistance heating element and has made it available for the construction of retorts and other apparatus where relatively high temperature is employed.

Resistance to Fatigue

Investigations of the laws governing fatigue failure in metals is of great importance. The rather commonly accepted idea that metals, like human beings, recover their strength on resting after work seems to be supported by experiment. It is not claimed, however, that the analogy can be carried further, and the reasons for this must be regarded as different. The most extensive work of this kind has been carried out under the direction of³⁰ H. F. Moore in co-operation with the National Research Council. By testing successive pieces with diminishing loads, a load is found at which the life is indefinitely long under fatigue test. This is called the endurance limit. Such a method of test, which necessarily involves many millions of reversals, is extremely tedious. Moore³¹

²⁹ *Trans. Am. Soc. for Steel Treating*, 1922, 21, 384-386.

³⁰ Bulletin 124, Univ. of Ill., Eng. Exp. Sta., Oct. 31, 1921.

³¹ Bulletin 142, Univ. of Ill., Eng. Exp. Sta., May, 1924.

and Kommers have devised apparatus which overcomes this difficulty. When the results obtained by the ordinary method of test are plotted, load against number of reversals, a sharp break in the curve is noted at the endurance limit. In a modified type of machine, a contact thermocouple indicates the change in temperature which corresponds to the change in stress. These results, when plotted, show a break in the curve at a load which corresponds to the endurance limit. With this procedure, it is necessary to take only temperature and load readings to find the point. They have found that pieces undergoing this form of test are very much influenced by the character of the surface finish. Cold working tends to increase the endurance limit somewhat, but not in proportion to the increase in static elastic limit. Increase in static tensile strength is not a reliable indicator of the increase in endurance limit.

Failure under fatigue tests causes the material to present a short fracture in which there is an absence of any evidence of ductility. This is because failure is in the nature of a progressive slip, starting at the most strained fibers in the outer surface. Slip starts in one of the crystals and continues either into the next one or until it meets some obstruction. In the latter case, a new slip starts with similar outcome. This continues until failure occurs. In test pieces symmetrically loaded there is usually an area at the center, the so-called neutral zone, in which fracture is of the normal kind, and which has a different appearance from that of adjoining areas. One often hears the remark made upon examining a piece of broken metal, that it is crystallized and has failed from fatigue. Of course, all metals are crystallized and whether

failure is from fatigue or some other cause can usually be told at a glance.

THE FUTURE OF RESEARCH IN METALS

It is not many years since the beginning of chemical control in the manufacture of steel. Until that time, the only control was in the art of the melter. Exact chemical analysis made it possible to trace many relations between properties and composition. As a result, steel was made and sold to meet a specified composition. Another great advance in the study of metals was made with the advent of metallography, when metals were first studied under the microscope. This added immeasurably to the control of properties in metals. The investigations which it suggested made clear the importance of crystal structure. The presence of certain constituents or aggregates was noted, and connection established with the physical behavior of the metal. Great improvement has occurred in the manufacture and heat treatment of metals in consequence of these discoveries. But in spite of all of these advances, there yet remains much to be done. We may seriously ask ourselves not why metals are so strong, but rather why they are so weak. Calculations made by Griffith³² indicate that the absolute cohesion of metals might be expected to result in a tensile strength of 5,000,000 pounds per square inch instead of 50,000 pounds which we find in iron, or less in many other metals. The trend is still towards the study of the smaller elements of structure. The period of X-ray spectrometry and spectrography which we are just entering, through its ability to give us knowledge of the arrangement of the atoms themselves, gives great promise of further interesting revelations.

³² Phil. Trans, Series A, Vol. 221, pp. 163-198.

Research in the Artificial Silk Industry

By S. S. SADTLER

President, Samuel P. Sadtler & Son, Inc.

RESEARCH in general is defined as careful and diligent investigation, seeking for facts or principles. It should also be considered as embodying intelligent, trained and thorough effort. Research should only be undertaken by competent people or the effort may be wasted. Of course, an inspired worker can do more than one who is not inspired or who has very little incentive. Under modern conditions of specialized training, research to be successful should be conducted by technically trained people and if it bears on manufacturing processes it should be organized or composed of separate and articulating parts.

There are two main kinds of research: pure and applied. Pure research is supposed to be undertaken for the general advancement of knowledge by educational institutions, governments and by trade associations. Ordinarily there are supposed to be no immediate, financial returns from pure research. But the fact is that being fundamental, the returns that come from this source are the largest, and really new truths are discovered. Then there are by-products of pure research that are of a distinctly practical and remunerative nature. All large organizations which can finance the work through a period of years should engage in pure or fundamental research. Applied research is the subject of this paper, however, with particular application to artificial silk.

In earlier times men were to be found who were so far ahead of their fellows or had so much more and better training than almost any one with whom

they came in contact that they were self-organized or, in effect, organizations in their single persons. This situation was prevalent in the early days of modern chemistry and running through most of the 19th century. A man of genius with the patience to study many branches of science and with untiring energy, often undertook work that now-a-days would only be considered by a more or less diversified organization. This condition does not obtain today.

The inspiration of a directing head is of prime importance today. The extent to which the Chief can inspire his individual workers is in inverse ratio to the amount of detail direction that will be required. A research organization cannot function efficiently without an *esprit de corps*. Some "soul" must be put into the work.

THE REASONS FOR RESEARCH

In general, research may come about from two standpoints. First, the urge to research. This practically brings us back to the individualistic method or it may be at present in many cases only the working-out of one's hobbies. While this has its well established place it is not quite the subject of this paper. Second, the research from demand.

Demand for research is the outcome of our complicated artistic and luxurious civilization. These propositions may seem to be independent but in reality the two latter are the causes of the former. Because we want things both beautiful and convenient we must develop the intricate and elaborate means of producing the finer things for living.

If people only wanted what was most efficient, convenient and artistic and had settled tastes, industry and research would probably not be operated at the intensive rate they are at present, especially in this country. In Europe there is, or at least was until very recently, a satisfaction in having things well made and when one possessed these things he became satisfied and the articles became cherished possessions as long as they lasted. It is needless to go into details as this characteristic of Europeans is quite well known. This picture is really underdrawn as there is a veneration for old things that seems to be stronger as one travels around the world from the United States eastward to China, where the reverence for old things is extreme. The desire for novelty, therefore, is a great factor in modern life and affects research.

Competition is the life of trade and consequently of research. Manufacturers probably improve their methods largely because others do. They often increase their production because others would if they did not. The proper extent of production can only be determined by research.

IS THE COST JUSTIFIABLE?

The cost of research will be a percentage of the value expressed in dollars. They should be considered as entries in the capital account. Governments, however, could not issue bonds to cover the estimated cost of research nor could corporations, if the plan were disclosed. The reason for this is the risk. I will assert, however, that the risk of well considered and well planned research is vanishingly small, especially when planned by business interests having a well conceived objective. If the projectors do not secure the results at which they aim, they secure others (by-products) of the original research or they find that the objective cannot be

obtained and so concentrate their efforts on what they already have. Now the investigators know that they are pursuing the right course and they cannot fail if confident energy is exerted in the right direction. That research is costly is to be expected. Knowledge is the most valuable form of property we have and who expects to build with bricks and mortar for any small sum. Expense merely leads to efficiency.

The only arguments that I will advance to show that the cost of research, though high, is reasonable, are: First, Europeans are noted for their conservatism, as compared with ourselves, yet they have led us in research. That we have gone ahead in wealth is due largely to our natural resources which were believed inexhaustible (but have now been largely squandered); to our unity; and to our quickness of perception; but not to our thoroughness and attention to details. Second, practically all of the modern successful corporations in this country have found it profitable. The profits are generally substantial and thousands of per cent are not at all unusual. If known accurately profits are not always quoted to the research staff.

Valuable lessons can be derived from a study of the course of research in artificial silk production. When organized research has been conducted in the artificial silk industry, very remunerative returns have been obtained. The great mass of scattering patents indicates that considerable research, poorly supported and poorly organized, was carried out and failed. I have personally known of a number of non-technical or untrained men who came to this country and started ill-advised operations. How many more there were in this country and especially in Europe I do not know, but estimate them to be many in number.

The only cases of well organized re-

search in this field of which I have knowledge, were successful. In well organized research, failures to accomplish certain ends are valuable as negative results and tend to narrow the field and bring us that much nearer to the goal of success. The most successful and best known silk research enterprises undoubtedly were the Tubize development of the Chardonnet process, the Viscose processes of the Courtaulds, Ltd., the duPonts, the Glanzstoff method of making filaments from a solution of cellulose in cuprammonium and the more recent product made by spinning a solution of cellulose acetate.

I shall discuss these processes in a very brief and incomplete way and more from a controversial than technical standpoint. As to the technical side there has been some effort to report the important processes but naturally valuable secrets are guarded jealously. What have found their way into print are, in a measure, the secrets that have leaked out and patent disclosures.

THE CHARDONNET PROCESS

Count Hilare de Chardonnet, though not the first experimenter in this field, was the first to obtain valuable results. If Chardonnet had not been wealthy he doubtless would not have succeeded. I do not know when he really began his studies but doubtless long before making things public. He is said to have first of all studied the silk worm in the south of France and tried to imitate the spinning method of the worm (*Bombix*) by artificial means. He first used Mulberry twigs and leaves as the basis of his colloid, to find later that he could perfectly use a fairly pure form of cellulose. He placed his plan of procedure in the hands of the *Academie des Sciences* in 1884. It was not until 1891, however, that a small factory was put in operation at Besançon, France,

certainly ten years after he started. Then it was some years after this before the silk was even reasonably satisfactory.

As an instance of a commercially successful research I would not choose the work of Chardonnet, but this does not detract from the honor that should be accorded this pioneer. The more honor is due him as he worked at fundamental research and the result was the great by-product of the artificial silk industry. He worked unselfishly as only the fortunate may.

That the original company which took up the Chardonnet process did not succeed as well as the company formed to operate this process at Tubize, Belgium, is probably due to the fact that the Tubize Company early had intensive and adequate research and while I do not know the particulars of the company at Besançon as I do of the Tubize, the works of which I have visited several times, I believe I am right in saying that the former company did not have well organized research.

An account of the Chardonnet process in 1887 shows a very crude product. The turbid collodion was clarified by the precipitation of zinc or iron tannate in the solution and then spun into dilute nitric acid instead of water. The account does not mention washing with water, but whether or not this was done the filament, unless dyed or stained, was gray or black in color and relatively unattractive in appearance. It must, however, have given promise or the work would have been abandoned.

In 1888, Chardonnet speaks of using either sulphite wood pulp or cotton, but finally settled on the use of cotton. He apparently at this time spun into water and denitrated with nitric acid of moderate strength, in contrast to his original method. In 1895, artificial silk still seems to have cost more than natural, but the hope was expressed by

Herzog that it could be made more cheaply. The denitration of the filament was later accomplished in a better way by the use of sulphohydrates.

Chardonnet in 1893 patented the use of hydrated nitrocellulose in making the collodion. This may not seem to those who have not followed this art as being very important, but it was rather revolutionary as it obviated the necessity of spinning into water. The spinning now took place in air and the spinners were in a case that was designed to collect only the vapors of the solvents coming off from the filament. This air laden with solvents was now taken off and wasted for some years but later a process of recovery was worked out and installed.

LACK OF VISION

To show the lack of imagination of many generally successful business men, according to the U. S. Consular Reports, December, 1894, we learn the Lehner (modified Chardonnet process) was started in England with \$500,000 capital. The report of the Bradford Conditioning House was quite favorable. The rather general opinion in Bradford was, however, about as follows: It was doubted if it could ever be produced in quantities great enough to make it a factor in trade, although it might have limited consumption as a weft (filling) with other warp material. Conservative textile people would not take it up and consequently the enterprise failed.

In Germany at this time it was said:

Reports of experts have decided that artificial (celluloid) silk is much inferior to the natural article on account of higher specific gravity, less elasticity and above all its inflammability. Furthermore, its manufacture is difficult and only a very small quantity can be put upon the market. Serious competition with natural silk and silk products is out of the question.

Probably the German experts were right technically but lacking in imagination. This in many respects is better, however, than being highly imaginative but lacking in technical training and acumen.

In a report of the U. S. Consul at St. Etienne, France, in March, 1893, speaking of the process, he says that the thread which was made from wood pulp is rendered as slow of combustion as other textile material by special treatment. He also says that the frequent snapping of the threads caused by unequal pressure made such differences in weight and loose ends that the product was comparatively worthless. His trite remark in summing up was to the effect that capitalists, while interested, were prone to await developments.

OTHER PROCESSES AND RESULTS

These reactions in 1893 indicate to us the psychology of many, if not most, men of affairs of all ages. They will let some one else bear the burden of the research and if successful will endeavor then to obtain benefits therefrom. Most inventors die poor. Some are allowed a bit of fame which does not cost anything. On the other hand, this aloofness of industry until a process is fully developed is a great stimulus towards producing the most perfect products. After all, why should any one take risks that do not seem judicious? It is better to miss participating in a profitable venture than to embark in a poor one.

In 1892, F. Lehner in Zurich made improvements by heating the nitrocellulose used to make the collodion solution with some strong mineral acid. We know now quite well how acids will modify the viscosity of cellulose solutions, whether afterwards nitrated or dissolved in cuprammonium. Lehner also improved the filament by denitrat-

ing in ammonium sulphide solution in a way very similar to what is now affected.

This research by another worker illustrates the value of co-operation or collaboration. If the result of an important invention is to be kept in the hands of the originators or a single group of capitalists, it is generally necessary to so organize the research that men of different specialized training can attack the problem so that time may be saved and the end really obtained by the projectors and not left for some better or differently trained inventor to pick up and make commercial.

It had apparently taken from six to ten years to produce a reasonably well denitrated filament by the general method of Chardonnet. Still the process was far from successful and although this artificial silk had a market, it was probably not until the factory was fully established in Tubize, Belgium, that a satisfactory article was made at about the time the Chardonnet patents had expired.

Nowadays a financial group or corporation who purchase or develop a basic and valuable discovery expect to have the larger part or, indeed, all of their 17 years of monopoly.

We can continue the study of research as applied to artificial silk in considering the Viscose process. Viscose filaments are made by the interaction of cellulose, sodium hydroxide and carbon disulphide. This forms what is known as cellulose xanthate. This is quite soluble in water and after the solution is properly clarified it is passed through capillary jets, known as spinnerets, into a strong acid solution, thus forming the filaments. After the filaments are obtained the processes are essentially textile in their nature.

This xanthate material was discovered in 1892 by the English cellulose

or paper chemists, Cross, Bevan and Beadle. They described this new chemical and discussed possible uses for the same, but they did not seem to refer at first to making textile threads. A commercial way of making filaments of Viscose was not discovered until 1903, when Stern found that ammonium salts could be used to precipitate this solution. Furthermore, it was some time after this before the more practical means of precipitating the Viscose as insoluble filaments, with sulphuric acid, was adopted.

It does not look as if our English friends had been very prompt about organizing research in this field, and, judging from the patent literature, organized research seems in all the processes to really begin about 1906. As far as English textile people are concerned, it is stated that they were watching results in France, and believed that if artificial silk proved to be an important element in commerce they would "jump in" and make the most of the situation. They were not all of this mind, however, as some held the belief that people abroad who were already in the field and had trained technical staffs would probably keep the lead commercially.

Although France, Belgium and Germany were in the field with successful enterprises using the Chardonnet and the Cuprammonium methods, the research work of Samuel Courtaulds & Company that was established at Kew developed a new process that has had the greatest production of all. This must have been really organized research work. The time of this intensive research work in England seems to coincide with the more intensive work that was done in Belgium, and was immediately followed by important work in Germany, when the method of spinning cuprammonium silk was changed from the acid to the alkaline

method with great benefit to the quality of the silk.

Viscose silk was soon so well thought of that factories were established in Germany, France, Italy, and, I believe, Belgium. It became at once the cheapest silk to produce, and this may be the cause of the intensive research work that took place in Belgium and Germany. The German article was, furthermore, inferior, as it was rather wiry and possessed too much lustre to simulate the product of the silk worm. The people operating the Chardonnet process had to look for means of effecting economies. They decreased the amount of solvent used per pound of silk by lowering the viscosity of the cellulose, and introduced effective means of recovering a large percentage of the solvents (ether and alcohol) used. The Viscose process was fortunate in using water as a solvent. I have already called attention to the use of considerable water in the collodion used in the Chardonnet process as a result of research work carried on some years after the work was started.

The Cuprammonium process was essentially a German development, although the real inventor was Despeissis, a Frenchman. Despeissis died, however, before his patent could be issued, and according to French law, the patent could not be granted to his heirs, as it could in this and other countries. This was in 1890, and it was not until 1897 that Pauly repatented the process.

The cellulose was dissolved in an ammoniacal solution of copper salt, and the filtered solution was forced from spinnarets into sulphuric acid. About 1908, patents began to be issued for spinning baths made up of alkaline solutions, as it was found that they produced softer, more elastic, and less glossy silk. This process is relatively cheap, and by the improvement of

Thiele, very fine denier silk could be produced. Practically all of the efforts to make artificial silk in this country before the advent of the Tubize and duPont developments, and excepting the Viscose Company, were by cuprammonium methods. This may be due to the relative simplicity of the Cuprammonium process, but I am inclined to believe it is due to the greater number of workers from the German artificial silk establishments coming to this country. Although they were generally incompletely informed as to the exact methods to be followed from both a chemical and engineering standpoint, nevertheless, they were able to persuade capital to undertake enterprises, all of which failed. These failures were due largely to the lack of judgment of the projectors in not providing adequate research, for probably most of these technical or semi-technical immigrants had one man's share of information. It is probably true that most of them would not have functioned very well with a director of organized research. There would have doubtless been "Distrust" with a large "D," but that need not have prevented the work being carried on.

A quite important artificial silk process is the Acetate process. Cellulose acetate is an ester of cellulose, made by condensing cellulose and the anhydride of acetic acid, just as Chardonnet or Tubize silk is made by nitric acid and cellulose. Nitro cellulose silk was, however, a mild explosive substance, so that it was soon found necessary to remove the nitric acid radicle. With acetate silk, this is not necessary or desirable. Acetate silk is not as much affected by water as the other silks so is as strong in the wet state as in the dry.

Cellulose acetate silk was first brought out in Germany, but important work has been done by Dreifuss, a Swiss

chemist, and Mork, Little and Walker, American chemists. Probably the effective work in making successful filaments of this silk is due to the chemists just mentioned. After this fibre was made, it was found that it would not take dyes like other varieties of artificial silk. It had some application as a resist fibre. Threads of acetate silk woven or knitted with other threads would remain uncolored, while the rest of the article would be dyed. This was too limited a use, however, so special organized research work was undertaken by the American Cellulose and Chemical Company. They developed alcoholic or spirit dye baths by which means they were able to dye acetate silk, but this was unsatisfactory.

An entirely different method was found by effecting a partial removal of the acetic radicle by means of the saponifying action of the alkalies. In this way, it would take dyes very much like other grades of artificial silk, but this procedure weakened the threads, caused loss in weight, and, doubtless, unevenness. Finally, they seem to have succeeded in finding a fairly satisfactory line or lines of colors that can be used in the ordinary way upon the unaltered acetate silk. This looks like a good piece of research work that has been quite effective, and should greatly extend the usefulness of acetate silk.

Adam Millar produced filaments by squirting hot concentrated gelatin solutions into air, and then winding the threads. These were then rendered insoluble by means of formaldehyde. The promoters of this process made great claims for this silk, which was known as Vandura silk, but while the filaments were insoluble, they swelled so much with water that they did not have strength enough to be used commercially. Recently, in this country, Little revived the hope that gelatin might be used to make artificial silk by

spinning into acetate. It might be desirable to have such fibres as they would be of animal origin like silk. But there has been little said about this process of late.

WHAT THE DUPONTS DID

We will now touch upon one of the most intense pieces of organized research work that has been undertaken in this industry. About the time the Tubize Company were co-operating with American capitalists in starting production of collodian silk in America, the duPont interests sent a "flying" squad of investigators to Europe with a view of finding the most available process to bring to America to serve as a means for the investment of millions of idle funds, and to enable the duPont Company, in part, to utilize an efficient technical staff that had been developed during the War, and for which it would otherwise have had no use. This was not entirely charitable, in effect, but in large part was a recognition of the capital asset value of an efficient technical staff.

After careful investigation of chemical, engineering and legal talent, under the direction of a competent chemist, rights to use the Viscose process of the *Société Française de la Viscose* at Arc-la-Bataille near Dieppe were obtained, and arrangements made for securing the necessary plans and data. The duPonts made these details their own, which only could be done with a fully competent research staff.

I do not know what the research work cost the duPont Company, but as they had a semi-works plant in operation for quite a period of time, it would not be surprising if it cost considerably over a quarter of a million dollars. I do not believe money was ever spent faster in research work by a single corporation, except similar work done by other elements of this research staff of

this same company when they undertook the development of a dye manufacturing company. This work has paid the company so well that since they started operations in 1921 they have enlarged their already large plant, and are now building another.

HAS RESEARCH PAID?

It might be asked which grade of artificial silk is the best. Each one has its field, in a measure. Certain people will only use Tubize or Viscose, duPont or Acetate, etc. The silks all dye somewhat differently, and have other special qualities. The company which has the most effective research work in the future will probably progress most rapidly. There is still a large field for research in modifying the qualities of the silk as to softness, opacity, strength, etc. A good deal of the necessary knowledge will probably come by obtaining more knowledge of cellulose itself. Research workers will look for an entirely different base than cellulose, and something distinctly different will result.

A great deal of the research work done in connection with artificial (now to be called "Rayon,") silk has been in connection with its properties, particularly its dyeing properties. Of course, a certain proportion of the technical work done by the important companies in this field is properly chargeable to control, and certainly most of the work now done is with a view of keeping the finished product up to standard and constant in properties.

To date I believe all the organized research work on making a marketing artificial silk has cost less than \$2,000,000 during forty years. The Tubize Companies have written off or carried to surplus, besides paying liberal dividends, several times this amount, and the Courtaulds have made, above liberal dividends, many times this amount. I believe both the duPonts and the American Tubize Company alone have each placed this much in surplus in the few years they have been in business. In view of all this, we may well ask—Does well organized research pay?

The Contribution of Scientific Research to the Development of the Portland Cement Industry in the United States

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HISTORICAL

ACENTURY ago, Joseph Aspdin, an obscure mason of Leeds,¹ England, was granted a patent by King George IV on an artificial stone which he called "Portland" cement, because of its resemblance to the well-known building stone quarried on the Isle of Portland,—the stone of which Westminster Abbey was constructed.

According to the fragmentary history of Joseph Aspdin, his patent followed years of experimenting, so that the present cement industry, which has developed from Aspdin's factory of 1825, was founded upon research. His plan of combining two powdered raw materials in certain proportions, burning them and then pulverizing the resulting clinker produced a cement much superior to the older hydraulic cements which were made from a single material that was lightly burned and then ground. The industry's surprising growth since Aspdin's time has been based largely on that same factor; today scientific research into the constitution and manufacture of Portland cement and its use in making concrete is going forward on a still more extensive scale.

PORTLAND CEMENT IN THE U. S.

The Portland cement industry in this country dates from 1872, when

¹The writer was present at the Town Hall Leeds, England, September, 1924, upon the occasion of the unveiling of a tablet in memory of Aspdin, at the joint centennial celebration of the discovery of Portland cement, held by British and American cement manufacturers.

David O. Saylor made the first cement of this type in eastern Pennsylvania. Here again success followed a period of experimenting, and while the equipment was crude, the work was based upon sound ideas. It was not practical for the American manufacturers to draw extensively upon the store of information then existing in Europe, and for many years development was slow. When a marked stimulus did come, it was through the introduction of new types of kilns and grinding mills which, particularly in the case of the kilns, followed a long period of often disappointing research.

Through further investigation, it was discovered how to utilize pulverized coal in burning the clinker, in place of the more expensive and less widely distributed petroleum. Natural cements have been made in the United States since the construction of the Erie Canal in 1820. In 1890, the production of natural cement was over 7,000,000 barrels, in comparison with a third of a million barrels of Portland cement. In 1900 the country's output of Portland cement exceeded that of the older natural cement for the first time.

There are now 134 operating Portland cement plants in this country, located in 29 states scattered from the Atlantic coast to the Pacific, and from the Canadian border to Mexico. The latest figures available from the U. S. Geological Survey show an output of nearly 150,000,000 barrels for 1924.

A better product, discovered and developed through research, has strongly entrenched itself, while the once firmly

established natural cement has almost disappeared from the market. Some writers have attributed the decline of the natural cement industry to the lack of an aggressive educational and promotional policy, based upon research, as much as to anything else.

COMPETITION WITH FOREIGN CEMENTS

An understanding of present conditions in the Portland cement industry and the part research has played in its development will be best secured by going back some three decades. In 1895 the domestic Portland cement industry, then 23 years old, was producing less than 1,000,000 barrels a year, whereas imports were about 3,000,000 barrels. Two years later the United States production had grown to 2,700,000 barrels, which for the first time was greater than imports. Three years later the annual output had more than tripled, and by 1902 had reached more than 17,000,000 barrels.

MANUFACTURE OF PORTLAND CEMENT

The manufacture of cement is fairly complicated because of the large quantities of materials that must be handled, and the close control of the ingredients that must be maintained at all times. The essential constituents of cement are lime, silica and alumina. These ingredients may be secured from a number of sources, the most common of which are limestone, marl and oyster shells for the lime; and clay, shale and blast furnace slag for the clayey materials. In the case of blast furnace slag, considerable lime is also secured.

Scientific research has made possible the utilization of deposits which once would have been considered unsatisfactory and has extended the possible locations of plants with a resulting saving to users of cement in various localities. Since cement is such a heavy, low-priced commodity, freight

rates make up an important part of the cost where the shipping distance is considerable.

The raw materials are quarried or excavated by powerful machinery and taken to the plant usually in cars. There the rock is put through crushers followed by various types of grinding apparatus until a material finer than flour is secured. Following crushing, the materials are weighed out in proportions determined by the chemist's frequent tests so that in grinding a very intimate mixture of the ingredients is secured.

The finely pulverized "raw mix" is now ready for the kilns, which are great steel cylinders, 6 to 10 feet in diameter and 100 to 250 feet long, lined with firebrick. The mixture is fed into one end of the kiln, which is slightly higher than the other so that as the kiln rotates the material slowly passes toward the lower end. The pulverized coal, fuel oil, or gas is blown into the lower end and burns in a great tongue of flame 30 to 40 feet in length, producing a heat greater than that required to melt steel. It is in this high-temperature zone that entirely new physical and chemical compounds are formed, called cement clinker. This is white-hot as it leaves the kiln, but upon emerging from rotary coolers it is ready for the storage pile or for the grinding mills.

Clinker, which consists of particles ranging from the size of a pea to that of a walnut, is glass-hard and is not affected by weather and needs only to be finely pulverized to produce cement. A little gypsum is added to control the rate of hardening of the cement.

Although a variety of machinery is utilized in grinding clinker, final grinding is commonly done in rotating steel cylinders partly filled with a charge of many tons of small steel balls. As the cylinder rotates, these balls are carried

part way up the side and then are thrown outward and down, resulting in pulverization of the clinker.

PROPERTIES OF PORTLAND CEMENT

No matter what raw materials are utilized, the resulting cement must have certain well-defined characteristics and must meet standard specifications which have been adopted jointly by the American Society for Testing Materials and the U. S. Government. The standard specifications require that at least 78 per cent of the finished cement be fine enough to shake through a sieve having 40,000 holes to the square inch. This sieve is made from bronze wire, but is woven much more finely than a silk handkerchief.

At the present time the quality standards of the cement industry are well established and all cement must meet these specifications. In the early days of the industry, a great deal of attention was paid to securing a product that would equal or exceed the imported brands and careful investigation was absolutely necessary in order to develop methods of quality control. In fact, it was only after the quality of the domestic product had been fully demonstrated that engineers adopted it. Without research the industry would never have reached a firm basis for its extensive later growth.

QUALITY CONTROL IN CEMENT PLANTS

Chemical and physical laboratories are essential parts of every cement plant, and are jointly responsible for the control of the quality of the cement. The first tests of the chemist are made on samples secured from the drill holes in the quarry, so that he knows what to expect from different parts of the quarry after the material is blasted loose. This control continues through the manufacturing process. It is the chemist's duty to set and lock the scales

which govern the proportioning of the raw materials, and to change the setting as the materials change.

The physical laboratory makes tests during the process of manufacture, but it is concerned chiefly with testing the finished cement to see that it conforms to the standard specifications.

RAW MATERIALS IN CEMENT

Perhaps some idea may be given by the following facts as to what it means for an industry to take some 48,000,000 tons of raw materials in the course of a year, put it through varied manufacturing processes involving more than 80 operations and from it secure 28,000,000 tons of finished cement. It is estimated that 11,000,000 tons of coal were burned during the year, in addition to large quantities of fuel oil and gas. In fact, the Portland cement industry is the fourth largest manufacturing user of coal and the largest user of pulverized coal.

Again, in breaking up the rock required as raw material, more than 17,000,000 pounds of explosives were set off in cement mill quarries during 1924.

Cement is shipped chiefly in returnable cloth sacks, four to the barrel. To replace the sacks lost and worn out in one year, a strip of cloth more than 37,000 miles long and 30 inches wide was needed. In addition to this, 50,000,000 heavy paper bags were used during the year. The most recent figures available from the Interstate Commerce Commission place the cement industry fourth among shippers of manufactured articles.

PORTLAND CEMENT ASSOCIATION

Here then was a rapidly developing industry, until a few years previous greatly handicapped by a marked preference on the part of the users for

the product of foreign competitors, but fortified with recent improvements in manufacturing methods that had made the rapid expansion possible. Yet the industry was without any well-developed plan or means of broadening its field of usefulness. In fact, many puzzling questions were before the manufacturers, and accordingly in 1902 a meeting of the producers in the eastern states, where more than half of the entire output was then made, was held in New York for a discussion of matters of interest. This first meeting was devoted largely to the troublesome question of containers for the product, but it opened up such possibilities of co-operative effort in solving common problems of manufacturing and market development that before adjournment a permanent organization was formed.

Within a year other manufacturers from the West had joined and national representation was secured. That organization is still in existence as the Portland Cement Association, which has as members nearly 90 per cent of the companies manufacturing Portland cement in the United States, and in addition, several companies operating plants in Canada, Mexico, Cuba and South America.

The one paid secretary of the first organization has now been replaced by some 425 employes of the present Association. In order that Association activities might be carried on with great efficiency and in the light of local conditions, 28 district offices have been established in all parts of the United States, and one in Western Canada. General headquarters are maintained in Chicago, where there is also a research laboratory maintained jointly by the Portland Cement Association and the Lewis Institute under the name of the Structural Materials Research Laboratory.

AN EDUCATIONAL PROGRAM

In effect, the Portland Cement Association is the educational-promotional-research foundation of the cement industry. It is not engaged in the manufacture or sale of cement, but carries on for the entire industry educational and promotional work "to improve and extend the use of concrete," all of which is based upon facts established by painstaking research within the industry and by other organizations such as the U. S. Bureau of Standards and various university laboratories.

The Association is a "Service" organization for the user of cement as well as for the manufacturer. Principal attention is given the educational and promotional work which has as its objective the extension of the use of cement. A secondary field of endeavor is the increased efficiency in manufacturing methods.

CONCRETE RESEARCH

In considering the major field of the Association's activity, that devoted to extending the use of concrete, the leaders early saw that increasing the use of cement through education and promotion presented some peculiar problems. Cement is practically never used alone, but is mixed with other materials such as sand and stone in making concrete and mortar. Because of the ease of transforming these various materials into concrete, a great number of people—some of them with very little practical knowledge of construction—soon began to make things of concrete.

Contrary to earlier accepted views, the way in which concrete is made has a great deal to do with the service it will give. Therefore, no matter how careful the manufacturers were in turning out a cement, it quite frequently happened that their product would be

incorrectly used and consequently dissatisfaction resulted which might strongly influence the builder and others against future use of concrete. The amount of mixing water added to the cement and aggregates—the sand and stone—in making concrete, the thoroughness of mixing, and the curing of the concrete, are some of the factors that govern the strength and quality of the final structure.

Realizing that the knowledge of concrete making had not kept pace with the development of cement making, the manufacturers recognized that the biggest problem before them was the education of the user in the best ways of making concrete.

In order that they might tell the user these important facts about concrete, the Association leaders knew that they must be sure of the basic principles and that led to one of the most important factors in the success of the Association's work, namely, the establishment of a department primarily for research on concrete.

Of course, a great deal of valuable investigation in that field had already been carried on. Many governmental bureaus, university laboratories, and others had conducted investigations; the difficulty was that the results lacked co-ordination, and in many instances were conflicting.

STRUCTURAL MATERIALS RESEARCH LABORATORY

In 1916, the Portland Cement Association joined with Lewis Institute, a polytechnic school in Chicago, in establishing the Structural Materials Research Laboratory, where research into matters pertaining to concrete making had already been under way for about two years.

Only eight members made up the staff at the time the co-operative work was begun, and the contribution of the

Cement Association during the first year was about \$15,000.

From the first, the value of this work was recognized, although it was four years before the first bulletin describing the results of some of the investigation-al work was issued. The Laboratory developed steadily and additions were made from time to time both to equipment and personnel. Space on three floors is now required, and a staff of about 40 is employed by the Laboratory. Tests are being made at the rate of about 45,000 per year.

Inevitably more problems in such a broad field as concrete construction would present themselves for consideration than could be given adequate attention. Therefore, the selection of the problems to be investigated has received most careful consideration. An Advisory Committee, consisting of representatives of Lewis Institute and the Portland Cement Association, determine the general policy and program of work for the Laboratory. Attention is focused upon one group of problems until satisfactory results have been secured, rather than dissipating the energies of the staff on unco-ordinated minor problems.

FUNDAMENTAL PRINCIPLES OF CONCRETE

The first important work of the Laboratory was to establish definitely the vital part that the water content of the mixture plays in determining the strength of concrete. It was found that the use of a pint too much mixing water in a batch of concrete was equivalent in its weakening effect to leaving out two pounds of cement. Therefore, this matter of maintaining a uniform and desirable consistency is extremely important.

Important studies have been carried out which gave a better understanding of the effect of size and grading of ag-

gregate, the changes in quality of concrete resulting from variations in cement content, effect of different foreign materials in concrete, and many other factors.

CO-OPERATION WITH OTHER ORGANIZATIONS

Much has been done in co-operation with other testing laboratories and technical societies, such as the American Society for Testing Materials, the American Concrete Institute, the Bureau of Standards, the Bureau of Public Roads, the Associated General Contractors, and the California Highway Commission.

Dissemination of the findings is given as complete attention as the investigational work itself; until this information is in the hands of the user of concrete, it has failed to accomplish the purpose of the cement industry in securing it. These results are frequently first given in papers before technical societies; later these papers are distributed in printed form. Other data are issued directly by the Laboratory as bulletins and circulars.

Facts from the Laboratory are given prominence in the literature of the Association and in some instances form the entire basis of the publication. Through articles in the leading technical journals, prepared both by the Laboratory and the Association, the facts are kept before those most interested.

CONCRETE ROADS

One or two instances will show what this research has meant to the users of concrete, and consequently to the cement industry, through the broadening of the market for its product because of the satisfaction and economy secured through the proper use of cement.

The concrete road is a comparatively modern development. As with any-

thing new, the first examples left much to be desired. It was only through careful study and research into better methods of building concrete pavements—first on the part of individual cement companies and later on the part of the Portland Cement Association engineers in co-operation with this Laboratory, all of whom worked with the governmental agencies most interested—that modern methods of highway construction have been developed. In the five-year period, 1909 to 1913, which comprises the early days of concrete roads, less than 1½ per cent of the cement produced in the United States was used in pavements. In the five-year period, 1920 to 1924, this was increased to nearly 20 per cent. At the present time, about 25 per cent of the cement made is being used in pavements of various classes.

CONCRETE AGGREGATES

In some parts of the country, it has been difficult to secure satisfactory aggregates at a reasonable cost for use in building concrete highways. In one instance in a western state, it was necessary to open a quarry and set up a crushing plant near the job. But the rock was of such a nature that crushing produced too much of the smaller pieces. In making concrete in accordance with the usually accepted specifications it was necessary to throw away more than one-third of this crushed rock.

One of the fieldmen of the Association suggested to the engineers in charge that the Laboratory might find means of utilizing some of the wasted material. Accordingly, the problem was submitted to the Laboratory with samples of the crushed rock. These samples were carefully examined and the usual concrete tests made. To the results, we applied the systematized knowledge gained in thousands of

earlier tests and were able to recommend a mixture of fine and coarse aggregates so that nearly all the material could be utilized without sacrificing any of the strength of the resulting concrete. These recommendations were put into effect; on this job alone the saving amounted to \$30,000, or more than enough to build another mile of concrete road.

RESEARCH APPLIED TO FIELD CONTROL

There are always those who contend that the results of laboratory research may be theoretically correct, but are not practical in the field. But this objection cannot be raised in this case, because many prominent engineers and contractors have applied the results on important jobs, and the principles announced from time to time are now accepted by the construction world.

One interesting example of the application of laboratory principles to concrete construction is found in the bridge built by the Big Four Railroad over the Miami River at Sidney, Ohio. Twenty-eight thousand cubic yards of concrete went into this bridge, all of which was placed under scientific control. Instead of using arbitrary proportions of the aggregates, guessing at the consistency of the concrete, and trusting to luck for curing, the mixture was designed for the desired strength on the basis of the aggregates used. Tests were frequently made to control the consistency and modern methods of curing were employed.

This research is not confined to the laboratory. Whenever desirable, tests have actually been made on the job in studying the efficiency of various field methods. During 1923, important field investigations were made in the vicinity of New York City and Philadelphia during the construction of seven large reinforced concrete buildings. These tests were made for the

purpose of determining the uniformity of concrete under job conditions by the usual methods of proportioning and control.

In 1924, tests on curing of concrete roads were carried out in California in co-operation with the State Highway Commission.

CONSERVATION OF POWER

Through the Portland Cement Association it has been possible for the manufacturers to co-operate in effective research into many subjects involved in the making of cement. This work has been carried on chiefly through a Conservation Engineer working under the direction of a Committee on Conservation, the membership of which includes representative cement company officials.

An outstanding example of this research is found in the utilization of the hot gases from the kiln in generating steam for power. Because of the high temperature (2,500° to 3,000° Fahrenheit) required near the lower end of the kiln in order that the raw mixture may be changed into cement clinker, the gases emerging from the kilnstack have a temperature of 1,000° to 16,000° F. The volume of these hot gases is very great, hence it has been found entirely practical to utilize them in heating boilers which generate from 50 per cent up to all of the steam required to furnish power for the plant. Since the power demands in cement making are extremely heavy, this is an important matter. Of course, large expenditure is required for the installation of a "waste heat" system, but the eventual saving is considerable. The adoption of waste heat boilers has been rapid, and approximately 50 plants either have them in operation or in the course of installation.

Other matters recently investigated are the factors influencing the ease of

grinding cement clinker and the efficiency of different grinding media, the fineness of grinding of the pulverized coal so widely used as fuel in the kilns, and the various types of refractories for lining kilns have also been studied.

PREVENTION OF PLANT ACCIDENTS

Through the co-operation of the Association with the individual companies, the number of accidents in proportion to the man-hours worked in the plants has been much reduced. Statistics for 1923 show a reduction of 17 per cent in accidents in the cement industry, whereas an increase occurred in accidents throughout industry in general.

STUDIES OF CONSTITUTION OF PORTLAND CEMENT

At the present time a most thorough investigation into the constitution of Portland cement is being carried on in co-operation with the U. S. Bureau of Standards. Although methods of manufacturing cement have been carefully worked out and considerable study given the chemistry involved, investigation has not thus far given positive information concerning the real constitution of Portland cement as dis-

tinguished from its composition and has failed to explain the hardening process of the ground clinker. Here the latest developments in the chemical and physical sciences are being employed in a study of these obscure questions. While several years may be required to complete these investigations, it is anticipated that the work can be carried to a successful conclusion and will provide basic information of much value in the future development of the use of Portland cement as well as in its manufacture.

No better grounds for the promotion of concrete for use in any particular structure can be found than the strength, economy, permanence, and satisfactory service of similar structures already in use. Such examples can be secured only if the ingredients of concrete are good and, furthermore, if the concrete itself is properly designed, mixed and cured. The discovery of the basic principles underlying success in concrete making has called for extensive research, and it is only after the results of this research have been adopted that the foundation for the future success of the cement industry has been made more secure.

The Dependence of Purchasing Upon Scientific Knowledge

By C. E. DEVONSHIRE

Dennison Manufacturing Company

THE merchandise buyers for the large retail stores have always "bought" whereas the purchasing agents of industrial organizations until recently have always been "sold." The transition from a receptive to an initiative attitude probably best describes the evolution of the work of the purchasing agent.

The development of the buyer is comparable to the development of the salesman. In the primary stage, the salesman is an "order taker" and his counterpart is the "order giver." The purchasing agent's next step of waiting for the salesman to call has its counterpart in "high spot selling" when the salesman calls where he knows an order is to be given. The promiscuous sending out for quotations is not dissimilar to the circularization method of the selling end. Finally, the salesman who really sells, creates his market from a possibility and so the purchasing agent to do an equivalent piece of work must know his requirements as thoroughly as his markets and with these as a base must develop his best possibilities into competent suppliers.

This leads naturally to the traveling purchasing agent, for in no other way can the buyer have a real appreciation of the size and stability of the concern with whom he does business, their ability to make dependable deliveries and to maintain quality, their equipment and personnel. Still more important, the traveling purchasing agent can much more effectively detect new sources and discover new goods than

if he stayed at home. Therefore, by traveling added to his office records including trade directories, he knows his sources; but to know his requirements—what, how much and when to buy—in the present advancement of business means a considerable organization.

He must be intimately in touch with the finances of his organization to know how much cash is available for his use; he must be closely in touch with sales, anticipate results of selling drives and must not be overstocked if sales are coming hard; he must be closely in touch with merchandising to suggest new materials for old items of manufacture or to suggest new items to manufacture; he must know well the processes of manufacturing in his own plant and the particular demand each material is to meet.

The salesman generally must know one product intimately, the buyer should know (not infrequently) equally well over one thousand. Obviously this is not possible, so he leans upon professional knowledge in the form of chemical and physical laboratories and experimental departments. Finally the buyer must know how much to buy and when to buy, whether to carry a heavy inventory in anticipation of advancing prices or whether to secure turnover. The more or less elaborate office force of the modern purchasing office in conjunction with the work of a statistician provide him with this varied information.

GENERAL AIDS AND GUIDES

The various records of a purchasing department such as sources of supply, quotation files, catalog files and records of previous purchases are so generally known now that detail description in this article is unnecessary. There are a few newer aids which have been found of assistance. An information file attempts to keep as a permanent record all the information about each particular item which was previously in the head of the buyer only. In this record is kept not only the particular demands to be met by an item, but also factors to warn the supplier to avoid, methods suppliers have found useful in preparing the item and a short history of troubles with that item. A somewhat similar historical record is kept of the experiences with various suppliers of each item. Some purchasing departments are now gathering a museum of unusual materials for which they now have no demand but which may prove useful for future service.

In a large organization where several buyers may be working under one purchasing agent, some method of control is necessary for the chief. One method of doing this is to have commodity lists, possibly a dozen, each headed by that basic commodity, as copper, cotton, pig iron, etc., which is the primary factor in causing price fluctuations in the other purchase items in the list. Thus the list headed by copper might contain brass pipe, copper wire, copper anodes, etc. The various items in the list are purchased by the assistants so the chief follows the market on the dozen main items only, instead of attempting to follow all the detail, and as his plan of purchase changes he instructs his assistants to buy one or six months' supply of the items on the copper list if that is his

wish. In this way he has an absolute control.

THE MIDDLE PATH

Buying can no longer be done on a hit or miss method. A single bad purchase may cause failure of the company and if not failure a multitude of lesser ills—all very real, however. Some basic policy must be followed. A broker may legitimately figure that the profit he makes from buying and selling merchandise must be his first consideration, but the buyer for a factory has a fourfold problem, each division of which is equally important; that is, to have material of the right quality, in sufficient quantity, at the right time, at a price which will make the manufactured article salable in a competitive market.

The most conservative way to handle the price factor of this problem is to buy continually in just sufficient quantity to meet the immediate manufacturing demand.

The other extreme is the buyer who will take a chance and gamble on large quantities without proper investigation.

In the first case the buyer never takes advantage of low markets and so loses the opportunity for his house for profit on raw material; whereas the second man, by speculation, takes far more losses than are necessary and, in all probability, over a period of years is worse off financially than the too-conservative buyer. It is the fear of the speculator which leads many men to the super-conservative method.

There is, however, a path midway between these two extremes which in large measure combines the safety of the conservative buyer with the price advantages to be gained from speculative buying and this course is that most generally followed in American companies today.

Under the conservative method of purchasing, the purchasing agent need know nothing of markets or business cycles, but the moment material is bought ahead, very close contact must be kept on the markets and their relations to general business.

This is illustrated by the basic principle followed in purchasing from a price standpoint.

WHEN TO BUY

One buys from hand-to-mouth at peaks of either good or bad business because when business is at the peak of prosperity all commodities also are at their highest price and when the downward swing comes one does not want to be loaded with raw material bought at the highest price.

Everybody would like to buy at the bottom, but the bottom is difficult to foresee until the corner has been turned. When one is sure this turn is made, buy heavily, decreasing as it is thought another high peak is approaching.

On the dropping curve, from good to bad business, action is exaggerated, believing it better to pay for express and telegrams rather than to take large losses in raw material.

Now it is perfectly obvious that if one is able to locate this position on the business cycle and follow the basic principle, one will always be well bought. It is not difficult to save money in purchasing just after we have passed the low point of depression, for every purchase will prove profitable, but as we go up the curve of improving business our problem becomes far more difficult and markets must be followed far more closely.

Just before the break comes, everybody is busy, deliveries and transportation are in their most difficult position and the factory organization is crying for raw materials and more raw materials. This is the point where statistics

and experience must guide us, and the point where, if we wish to remain in the conservative and keep out of the speculative class, we must be guided by cold facts and not misled by superficial conditions. One is *never* justified in buying ahead to beat price unless available statistics prove a saving will result.

To justify itself from a price standpoint, the purchasing division must, over a period of years, have bought relatively more of each commodity below than above the average price of that period.

NECESSARY INFORMATION AVAILABLE

From a buying standpoint, knowledge of price of any commodity is not sufficient; the reason for that price must be known before intelligent purchasing can be done. To furnish this knowledge, the leading trade papers must be read religiously by the buyer. The purchasing division must subscribe to daily business papers, various trade papers, and avail itself of the service of various business bureaus such as Harvard, Babson's, Brookmire's, etc.

Salesmen calling are a mine of information and other buyers a great help. Trade associations are a prolific source of reliable information.

Underlying conditions which may affect a purchase must be correctly interpreted. Always the proper season to order must be kept in mind.

All these factors are considered besides information furnished by the statistical department.

In the old days the purchasing agent first started using just a plain price curve and it was splendid as a history—but after one became accustomed to a price range, it was of little or no use in predicting price movements. A first attempt at an improvement was to write the history of each curve and this helped but was not sufficient. The next step has been to carry three

curves for each major commodity, believing that the price of any commodity is affected by three primary factors—the purchasing power of that commodity, demand and supply.

VARIOUS STUDIES AFFECTING PRICE

One might attempt to forecast *purchasing power* by plotting the price action in conjunction with the Bureau of Labor Index of 404 wholesale commodity prices. Thus, if the price is above the average price, its purchasing power is high or, in other words, its price is out of line with other prices; and, conversely, if price is below average its purchasing power is low and its price is low in comparison with others. In using this curve it must be borne in mind that the relationship between prices of various commodities is always changing. Price curves like all other statistical graphs are simply pictures of experience and should be followed as such, remembering that they are "indicators" not basic facts.

Next, the *demand curve*. For this purpose the price of the commodity is plotted in comparison with general business. To represent general business the Harvard B line, the American Telephone & Telegraph Company line or Babson's X-Y line may be used.

The third consideration of the commodity is the *supply curve*. Here is plotted the price and the various supply factors affecting the price, as exports, imports, stock in warehouses and consumers' hands, etc. These all have some effect on the price.

So much for individual price movements, but, as mentioned previously, the purchasing agent must know his position on the business curve. This he tries to determine by studying all the information possible. Of course the various statistical services, the stock market and various rule-of-thumb methods, such as the price of

pig iron, help considerably. A study has been made of price action of various commodities over a period of years as compared with the Harvard B line to see whether there is any sequence to the changes and as a result a useful chart has been developed on which is shown the price of hides, cotton and paper. Generally the price of hides precedes, cotton goes with, and paper follows general business fluctuation.

One other useful study along the same lines is a graphic record of the number of increases as compared with the number of decreases in commodity prices as shown by the Dunn, Bradstreet, Fisher and Bureau of Labor commodity indexes. Thus the changes will show more increases than decreases or vice versa and as commodity price levels are comparable to state of business some relationship exists there. Usually the changes in business are preceded by a similar change in the relationship of decreases and increases.

GROWTH AND POSSIBILITIES

From the foregoing it can be seen that, whether or not the purchasing agent has charge of the raw material physically, he must be responsible for the quantity on hand and the amount to be ordered. At one time he should have a heavy inventory and at another it is necessary to reduce it to a minimum and turn it over as fast as possible. This can readily be accomplished by control, outgrowths of the old high and low limits.

This article has attempted to describe the growth in recent years of the work of the purchasing agent. The space allotted is too small to go into much detail in regard to the various factors. Volumes could be written of the statistical possibilities, the opportunity as a builder of good will, and incidentally the cash saving as a result of such good will, the possibilities the

purchasing agent has for reducing the selling and distributing expense of his supplying companies and the manufacturing expense in his own.

We who are associated with buying feel that what progress has been made is but a preliminary step in the right direction. Until very recently little thought has been given to this important branch of the world's business, whereas very complete study has been given merchandising, selling and manufacturing.

The year 1920 fraught with such disaster (almost always as a result of

poor buying) gave the work of the lowly purchasing agent a new stimulus. Since then executives have more fully realized the possibilities in this branch of their businesses with a resultant general improvement in personnel. The business schools are devoting much time to buying and the statistician is giving badly needed help so that the next few years should show tremendous advances and if, as we believe, we are entering upon a period of intense competition, this added efficiency in the buying fields will be most useful to our several companies.

The Evolution of the Work of the Purchasing Agent

By PAUL R. BRENNAN

President, New England Purchasing Agents' Association

IN the beginning let me say that the subject, "The Evolution of the Work of the Purchasing Agent," was not of my own choosing. I shall, therefore, proceed with a friendly and more or less unbiased discussion of the work, aims and ideals of the modern purchasing agent as I myself, a member of the guild, profession or craft of purchasing agents see them, letting you, the reader, decide as to whether this so-called modern purchasing agent has indeed progressed in his work or is still the gruff, grumpy, hide-bound old bear that Mother Goose sales managers picture him to their child salesmen.

Were I merely to assume that there has been a complete evolution of our work a strong case indeed could be made. Knowing too well our faults as well as our good points, I shall simply discuss various phases of our work and let you be both judge and jury.

Evolution we are told is an unfolding, a process of development, leading up to a definite result or end.

A purchase is an acquisition of commodities or materials for a price. An agent is one who acts for or in the place of another by authority from him.

Having thus defined the primary component parts of our subject, I will attempt by analysis to show the gradual development or evolution of the work of the average purchasing agent. In the first place, to my way of thinking the purchasing agent is a much misunderstood person. The average sales manager apparently works on the theory that the purchasing agent is a particularly nasty thorn set in his salesmen's path and he spends a

great deal of valuable time devising ways and means to get by Mr. Purchasing Agent and out back into the shop where "men are men," etc. This is indeed a profound mistake and a serious one. I believe that the salesman's best friend today is the purchasing agent, admitting quite freely, however, that very possibly the attitude of the purchasing agent of the past is to a large degree responsible for the generally biased viewpoint from which purchasing agents are regarded. We have, therefore, set up in the past a common barrier which in the development of modern ideas is gradually being levelled.

The average purchasing agent of not so many years ago was largely a price buyer, and he had to be, because there were so many different prices on the identical article or commodity that it was largely a battle of wits to smoke the dark-complexioned gentleman called "rock bottom quotation" out of the woodpile of so-called inside prices.

Quality, it is true, was considered but price was apparently of prime importance. Price today is of equal importance but is no longer regarded as the true measure of value. It is an item to be considered and that most carefully. Of far greater importance are those questions which deal with quality and adaptability of the article or commodity purchased to the requirements of the user.

The modern purchasing agent no longer buys on price alone and in this respect particularly has there been a decided development of thought,—or call it evolution if you wish.

ESSENTIALS OF A GOOD BUYER

Let us consider the knowledge absolutely necessary for a man to possess if he is to successfully conduct the purchasing for a modern industrial.

We will assume for the sake of illustration a factory manufacturing machinery and employing several thousand men. The plant is entirely self-contained and includes foundries, machine shops, woodworking departments, forge shops, in fact everything necessary to completely manufacture large production machinery on a big scale.

Let us enumerate a few things he will have to buy, and, buying, he will have to possess knowledge of them all. Remember, too, that he will conduct the bulk of his business with men who are specialists in only one of the particular commodities listed. Judge then the absolute need for broad-minded, keen visioned, far-sighted men sitting behind the glass door marked "Purchasing Agent."

Here is a small cross section of the list:

- Pig iron
- Coke
- Scrap iron
- Coal
- Lumber—hardwoods and soft
- Foundry machines
- Machine tools
- Small tools
- Foundry supplies
- Bar steel including
 - Cold rolled
 - Hot rolled
 - Soft steel
 - Tool steel
 - High speed steel
 - Alloy steel
 - Sheet steel
- Bar iron
- Oils (for cutting and lubrication)
- Printing
- Stationery

Castings including

- Gray iron
- Malleable iron
- Brass
- Steel

One could go on indefinitely listing dozens upon dozens of articles with which every progressive large industrial buyer must be familiar. The inventory cards of any large industrial will enumerate from 1,500 to 10,000 individual items.

Take hardwood lumber for instance. A man must know the grading rules, he should know the character and texture of the same kind of lumber grown in different sections of the country. Maple for instance grown in New England is different from that grown in West Virginia. White ash grown in New England and the Adirondack Mountains differs materially from that grown in Louisiana, and your purchasing agent must know this. Likewise must he know pretty well just where and for what purpose that particular size of ash, beech or maple is going to be used. It is only by possessing this knowledge that he can make a true comparison of price because price first of all is a comparison of values. Following along this line of reasoning, if a man does not know his raw materials how can he judge their value?

From the foregoing it can easily be seen that the modern purchasing agent must be fairly versatile. One might also gather that he considers himself all wise and omnipotent. Far from the truth and he knows it.

What holds true of lumber is also true of practically every other commodity he purchases. If you could but sit for a few brief hours behind the average purchasing agent's desk and "listen in" with him to the broadcast of the various salesmen as they tune in you could at least sympathize.

Let us sit in fancy a moment here while I go back to one or two of the men I met but yesterday. First, the oil salesman. He is all fitted out by his sales manager with a most elaborate leather kit containing various bottles showing oil in its several stages of refining. This salesman has been put through the oil company's school of salesmanship, visited the refineries for a short period and is now a full-fledged oil salesman qualified to advise the purchasing agent on his every lubricating need. The purchasing agent on the other hand has been buying lubricants for ten, fifteen or twenty years, has likewise visited a great many refineries and knows what he has to lubricate and in addition has a laboratory to back up his judgment. Who then is the best judge?

The next man sells twist drills. He will guarantee 25 per cent greater production with his drill than with any other drill on the market. This plant we will assume uses drills to the value of \$10,000.00 in a year. Here is a chance to save \$2,500.00 on one item alone. What are you going to do? Remember you are already using a drill that has worked out supremely satisfactorily after exhaustive competitive tests and under the most severe shop service. Mind you, this salesman may be right, but how are you going to determine it? Easy enough if the salesman seems sincere. If his house is reliable you will probably test out one or two of his drills under the most exacting conditions and if they show up well, develop the test still further and eventually you may save \$2,500.00.

The amount of paper profits that purchasing agents in general have saved their respective plants amounts to fabulous sums. Unfortunate it is that so many of these profits remain on paper. On the other hand, it is true that more money can be saved by

careful buying than many high priced sales managers produce in profits for their respective companies.

Buying campaigns are conducted today just as are sales campaigns. No longer are goods purchased haphazardly at any and every time. Likewise buying limits are set. These limits vary, depending upon the class of material purchased, its inventory value, its rate of use and also upon its (to manufacture a word) "storeability," meaning by this its ability to resist deterioration in storage.

To purchase certain commodities in a large way at exactly the right period of the year often necessitates knowledge of world-wide conditions and the modern purchasing agent to hold his job must know these conditions. Call this evolution if you will.

The present-day purchasing agent is no longer simply a desk man, although the bulk of his buying is done from his desk. It is a common occurrence today for the purchasing agent to visit the plant of his larger suppliers of raw materials and finished products to determine as to whether in his opinion they have the necessary plant and equipment to fill his most exacting requirements. For what good is it to your manufacturing department to know that materials are ordered and deliveries are promised but not forthcoming. More purchasing agents have been crucified on the cross of broken promises than any salesman can possibly imagine and I can assure you, some salesmen have wonderful imaginations. So much for the personal equation.

VALUE OF PURCHASING AGENTS' ASSOCIATIONS

Now let us look for a moment to the causes leading up to the development and evolution of the game of purchasing. First and foremost I would say unhesitatingly the purchasing agents'

associations. First, the local association comprising men in his city or state; second, the work done by the National Association of Purchasing Agents with whom all these smaller local associations are affiliated.

Our modern purchasing agent meets his fellow purchasing agents at least once a month and some associations meet at lunch every week to discuss problems of general and mutual interest. Then we have these various local associations divided into smaller groups of men all interested in the one commodity, such as paper, lumber or fuel and other such basic materials.

Consider if you will for a moment a score or more of representative paper buyers of New England meeting once each month for frank and open discussion. Look over the group. You will see printers, publishers, paper retailers, wholesale representatives of the greatest mills in every line: kraft, coated, tissues, boxboard, fine writings, in fact everything, all frank, open and honest. Where could more complete and accurate information be obtained? Call it evolution. It is the same with the other groups.

Let the seller beware, for the modern purchasing agents' association wields a powerful influence for good. Consider the work of the National Association in its plans for standardization of invoices, of inquiry forms, standardization of catalog sizes—indeed a boon to long suffering humanity. Consider for one moment the almost fabulous sums that can be saved to industry in general if complete standardization of but two of these items were to be brought about, namely, invoices and catalogs. The figures are positively startling. Call this evolution.

The national government at Washington appreciates the work started by the purchasing agents' association along these lines and has repeatedly called

representatives of the association into conference to work out plans of this nature.

Young Men's Christian Associations the country over are planning courses in purchasing both in their day and evening classes. Graduate schools include purchasing in their curriculum. Business forecasters regard the purchasing agents' association as essential to industry and often turn to these associations for information necessary in making their prognostications. Apparently we are making a pretty good case for evolution.

POWERFUL BUYER *vs.* SMALL ONE

Recently a prominent business man declared that the purchasing agent was the balance wheel of industry and it is thus that I like to regard him. He is a man of forceful character, not too opinionated but like the engineer with his hand on the safety valve. How easy it is for the careless buyer to commit his firm too deeply for raw materials or finished products. He is being constantly urged to buy, buy, buy. Every device and art known to the alert sales manager and his equally alert salesman is used to induce the buyer to sign on the dotted line, and he must know how and when to refuse. Then, too, what a responsibility it is to place squarely on the shoulders of one man the purchase of the entire requirements of a great industry.

It is true that if the plant be a large one there will probably be a number of buyers, some of whom specialize on relatively few commodities bought on a large scale. This is particularly true of the large public utilities where the purchase of fuel, their principal raw material, is often placed in the hands of one man, a fuel engineer if you will, whose job it is to secure to the best advantage the fuel best adapted to the needs of his company. He is a spe-

cialist but over him comes the general purchasing agent, oftentimes an officer of the company.

The mere title of purchasing agent hardly describes this man for he must be an executive of the highest type in order to meet the requirements of his position. He has at his command every resource of a great public utility. So, too, in the case of the very large manufacturing plants. The chief purchasing agent here has unlimited resources at his disposal for research and development purposes.

These men are paid salaries commensurate with the importance and dignity of their position. Their value to their companies is inestimable. They are indeed worthy of their hire. Their authority is unlimited, they possess the power to negotiate the largest contracts, and this is as it should be, for when the selling executive realizes that complete power to negotiate is placed in the hands of the purchasing agent, he wastes little time in attempting to influence anybody but Mr. Purchasing Agent.

Let us leave this big powerful buyer for a moment and turn to the great group of men buying for the smaller manufacturers and producers. Unfortunately very often indeed the power of these men (and they constitute a large percentage of the common everyday or garden variety of purchasing agents) is limited. Some are mere order placers, but happily enough the percentage of this last mentioned class is extremely low.

However, in a great many of our plants we find certain limitations placed on the powers of the purchasing agent. For example, in a certain plant the president of the company feels that only he is competent to purchase the pig iron; in another a vice-president feels that he must buy the crude rubber; another must buy all of the lumber;

still another the raw cotton and so on down the list, each man reserving to himself some prerogative which he feels is his by almost divine right.

Does he possess more complete knowledge of the basic markets on this or that raw material than his buyer? Occasionally, yes; more often no, and here is one place where evolution is still somewhat delayed. It is true that this evil—and evil it is—by slow degrees is gradually being eliminated. Unless the purchasing agent has complete power and authority to negotiate, his hands are tied to a great extent.

Industry in general is gradually awakening to the value of this concentration of the purchasing power and when a complete realization of the benefits to be gained by such concentration is gained, we will indeed have proceeded a long way in the evolution of our work.

POOR PAY

A word here relative to salaries. A purchasing agent is in reality a salesman of the highest order. Sounds paradoxical, but is it? He sells money, the dollars of his firm and for those dollars he must obtain the utmost in value. Handling every-day transactions, ranging from a very few dollars in value up to the negotiation of large contracts often involving millions, he must sell his firm's dollars to the highest bidder in value. For this service is he paid a princely stipend? Far from it.

I think I can say unhesitatingly that the average purchasing agent is one of the poorest paid classes of executives. Very often a purchasing agent whose yearly purchases aggregate a million or more dollars is paid less than his firm's most ordinary salesman and many, many times less than his own sales manager. Why is this? Well, a great deal of the fault may well be laid at the door of Mr. Purchasing Agent himself.

Too often in the past has he emulated the shrinking violet. Savings of tens of thousands of dollars made by wise and judicious purchasing he snuggles close to his breast. It is true that it's his business to do this, that it is all part of the day's work, but why not broadcast it a little bit once in a while? Let the big boss know something about it. Don't brag, mention it casually. He'll be glad to know it and he won't forget it when the rewards are handed out.

Frankly, the purchasing agent needs a lot of free advertising. Consider the case of the salesman who having sold a new account a sizeable order shouts the news from the housetops. Perhaps he should have been selling this self-same account for years; no matter, he has an order, and a big one. Does he simply mail it in without comment? Not so. If it's big enough and he is anywhere near home he brings it in person, at times to the president himself expecting, and generally receiving, flattering commendation. And this is all part of his job, just what he is being paid for. In my opinion he should be called down for not getting the business sooner. And generally speaking this man is paid more than the purchasing agent. Evolution? Well, some, but there is certainly room for more.

LITERATURE AVAILABLE

As to bibliography few indeed are the books dealing with the science of purchasing. A few men more venture-some than the rest have set down on paper their ideas as to purchasing procedure. The result, a very few books—possibly a half a dozen at the most—dealing with scientific buying, one magazine, a half a dozen or so association organs and you have the sum total of the literature on this subject. There is room here for evolution, surely.

Consider the volumes—nay the

tomes—dealing with sales, and advertising—a branch of sales. Were all of the literature to be gathered in one place on these subjects it would fill to overflowing a good sized public library. Contrast this with the record on the purchasing side. Quite a contrast! However, there is this to be said, what few books have been written are mighty good ones and well worth while. Undoubtedly more will be written as the ideals and ethics of the profession spread.

IN CONCLUSION

To sum up we can well say that there truly has been an evolution in the work of the purchasing agent; in some cases we might almost call it revolution. No longer does the purchasing agent of today treat salesmen as natural enemies; instead he regards them as real friends. Sharp practice and trickery have been eliminated to a great degree. The ethical standards of the profession are indeed changing and while cigars are still passed out in goodly numbers, petty bribery has been almost eliminated.

Commercial arbitration is being sponsored by the purchasing agents' organization and this, too, represents evolution of a high order. Altogether too many cases involving petty sums or differences are taken to our courts for adjudication. Commercial arbitration as advocated by the National Association of Purchasing Agents will remedy this sore spot to a remarkable degree.

Scientific forecasting has been of material aid to the purchasing agent in his process of evolution and will so continue. Many other causes might be cited but let us stop here and look over this newly evolved being emerging from his chrysalis.

Mr. Purchasing Agent measures up pretty well. Keen, resourceful, powerful, a student of economics, possessed

of a remarkable store of knowledge of raw materials and finished products. Having at his finger tips a thorough knowledge of sources of supply and of conditions in the markets of the world. Above all else, a gentleman of sound commonsense and unfailing courtesy. This represents an ideal modern purchasing agent. You shall decide whether we have made our case for evolution. I believe we have and in closing let me add just a few brief words about the latest development of

modern buying, namely, co-operative purchasing. To me this seems to be a source of fruitful endeavor. A wonderful opportunity to cash in on the value of organization. The grouping of purchases of like commodities by several plants means tremendous savings for industry over a period of time. This phase of purchasing is receiving very careful consideration at present and no doubt before long we will be carrying out on a large scale what has been well begun in a smaller way at present.

Costs as an Aid to Management

By G. CHARTER HARRISON
Stevenson, Harrison and Jordan

THE art of bookkeeping or accounting is of great antiquity and its origin is lost in obscurity. Babylonian records of account have been found written with a stylus on slabs of clay dating back as far as 2600 B.C., and to the accountant one of the most interesting exhibits at the New York Metropolitan Museum of Art is a model taken from a tomb of one of the Pharaohs representing a storehouse for grain, one of the figures in which is a scribe who is engaged in recording the sacks of grain being delivered by the roustabouts of that time.

It is interesting to note that while there have been many improvements in the technique of accounting throughout the ages, there has been little in the way of fundamental changes and it seems reasonable to state that there have been really only two basic improvements in accounting methods since the days of the Pharaohs, one of these dating back about seven hundred years, while the other is a development of the present century.

BASIC IMPROVEMENTS

The first of these basic improvements was that of double-entry bookkeeping, the essential features of which have been described by the well-known English writer on accounting, L. R. Dicksee, as follows:

The essential principle of double-entry is that it constitutes a complete record of every business transaction, and as these transactions are invariably cross-dealings—involving simultaneously the receipt of a benefit by some one and the imparting of a benefit by some one—a complete record of transactions from both points of view necessitates an entry of equal amount upon

debit and credit sides of the ledger. Hence it follows that if the clerical work be correctly performed, the aggregate amount entered up upon the debit side of the ledger must at all times equal the aggregate amount entered up upon the credit side; and thus a complete list of all ledger balances will show an agreement of the total debit balances with the total credit balances. Such a list is called a *trial balance*.

It is probable that the old adage, "necessity is the mother of invention," applied to the invention of the double-entry form of bookkeeping, for under single-entry accounting there was no automatic check upon the clerical accuracy of the records and mediaeval bookkeepers must have experienced many unpleasant half hours on those occasions when it was discovered that, due to taking off a credit balance as a debit one or vice-versa or to some other clerical error, the profit and loss statement previously submitted grossly overstated the profits. All accountants will endorse the statement that there is no experience quite so uncomfortable to an accountant as to be compelled to break the news to an employer that the good showing over which he rejoiced so greatly last week was purely fictitious and it was probably such an experience, demonstrating as it did the necessity for some automatic method of balancing, which provided the stimulus which resulted in the brilliant conception of the double-entry idea.

The second basic improvement in accounting was also a response to the stern demands of necessity, and the credit for this forward step goes to the engineer and not to the accountant. Curiously enough the professional ac-

countant who should have been the first to embrace so important an idea was the last to accept it; indeed, it was not until he woke up to the fact that his stubborn refusal to consider the views advanced by the engineers was gradually ousting him from what he had always regarded as being his exclusive field that the accountant cast aside his professional prejudices and joined hands with the engineer.

THE NEED FOR FORESIGHT

Now the disagreement between the engineer and the accountant was a much deeper one than a mere dispute as to accounting technique. It involved a diametrical opposition of view point. For centuries the accountant had been working along retrospective lines in preparing statements showing the result of the operations of last month and last year, in filling, and filling admirably, the functions of business historian. The engineer, on the other hand, had always lived more in the future than in the past. Foresight with him was necessarily a habit, for obviously he could not wait until his bridge was constructed to determine whether it would withstand the strains to which it would be subjected. The viewpoints of the engineer and of the accountant were therefore diametrically opposed,—the one looking always to the future, the other always to the past.

As manufacturing operations grew in size and complexity there developed a great need on the part of the manufacturer for information regarding his costs of operations. Very naturally he called upon the professional accountant to lead in the development of systems of cost accounting and, as was to be expected, the accountant followed what was to him the line of least resistance and developed his systems solely along retrospective lines.

And there followed what may be

termed an orgy of analysis. The accountant was convinced that if he could only furnish a sufficiently detailed analysis of expenditures all legitimate demands of the manufacturer for cost information would be met. The result was that cards of account became more and more elaborate, the cost accounting forces became larger and larger, additional calculating machines were purchased to grind out more and more pro-rations of burden expense and the factory employes were harassed with demands for more and more detailed information as to how they employed the time over and above that required for the filling-in of elaborate time cards. The final result of all this misdirected energy was a mass of figures of very little constructive value.

The manufacturer was presented with statements in the greatest detail showing the costs this month compared with the costs last month and the month before that. This information, however, was of limited value to him considered from the standpoint of showing him where his costs were excessive. This item of cost, for instance, was lower this month than it was last month, but what real significance did this information have when he did not know whether last month's cost represented 95 per cent efficiency or 45 per cent?

A FACT-FINDING COST SYSTEM

And this brings us to the crux of the whole matter. The amount expended means very little unless we consider it in relation to the value of what was produced as a result of this expenditure. The accountant in a broad sense was keeping his cost records on a single entry basis and was only keeping one side of the ledger, and the wrench that the engineer threw into the elaborate cost machine was a demand that the cost records should show both sides of

the ledger—not only what the costs were but what they should have been.

This second basic improvement in accounting is obviously merely a development of the fundamental idea underlying double-entry bookkeeping; namely, that all transactions are dual in effect. This double-entry cost accounting is known as standard cost accounting, which provides for showing on the debit side the actual expenditure and on the credit side the amount which should have been expended for the benefit gained or, in other words, the standard.

The prime purpose of management is the earning of maximum profits, and the value of a cost system considered from this standpoint is in pointing out to the manufacturer where the profits he should have made and did not make have gone. That is, a cost system should answer that old, old question, "Where have my profits gone?"

The main reason why inefficiencies remain uncorrected is because their existence is not known. The old time cost accountant was satisfied if his timekeeping system rendered it impossible to pay an employe for five minutes longer than he spent on the premises, but ignored the far more important question as to whether he only produced four hours of work during the nine hours he was inside the gate. The old-time cost system demanded that a day worker turn in complete details as to the time spent on each job, but provided no information as to the efficiency of the individual.

EXPLAINING THE "WHY" IN COST VARIATIONS

The earlier standard cost systems merely showed the expenses in relation to standard, but it was a foregone conclusion that as soon as the cost accountant came to a point where he was able to tell the president of his company that the actual costs were in ex-

cess of standard, the president was going to ask him "why?" As a result of this demand, standard cost systems have been developed so that they provide an analysis of the variations from standard costs according to the "causes" of such variations. The cost accountant is then able to advise the president that so much of the cost increase is due to idle time owing to lack of orders, to machines when operating producing less than the standard production, to labor inefficiency, to changes in rates, to increased power cost, to inefficiency in the use of power, etc. With such information before him, the plant executive is able to proceed directly to the root of the trouble, instead of beating around the bush as he was so often compelled to do under the retrospective method of cost accounting.

Standard costs are of supreme importance as an aid to management in disclosing the existence of preventable inefficiencies and thus pointing out the road to economies; but they are also of great value considered from the standpoint of giving the sales department information which will enable it to adopt price policies for the realization of maximum net profits under existing conditions. A cost accountant operating a well-planned standard cost system can very rapidly give accurate forecasts of what any article will cost to manufacture today, regardless of whether this article has been manufactured recently or not. In this respect the retrospective cost plan proved very defective. As an example—the sales manager was called upon to submit a bid for several milling machines. He would call his cost accountant and ask him what the machines would cost; but if this particular machine had not been manufactured during the last six months, all that the cost man could give him in the way of information would be what the ma-

chine cost to make several months ago, —the cost information representing a conglomeration of labor, burden and material rates extending probably over a period of many months.

ENLARGED SCOPE OF COST ACCOUNTING

An interesting feature in connection with the remarkable development of cost accounting in the last few years is the enlargement of its scope to include not only the factory but the selling and administrative fields. The cost accountant is beginning to realize that it is his function to disclose losses of profits not only in the factory but throughout the whole business. What does it profit a manufacturer if he operates at 100 per cent in the factory and then loses all the advantage of economical manufacture by wasteful and inefficient methods of distribution? Cost accounting is obviously lacking in filling its full function as an aid to management until it discloses all of the leaks in profits; it is as much the duty of the accountant to point out the loss resulting from the employment of an inefficient salesman as it is to disclose a loss resulting from an inefficient factory operative. As a matter of fact, the loss from the former is likely to be far greater than from the latter.

The complete cost system carries the engineer's idea of predetermination to its logical conclusion; not only are costs predetermined but sales expenses and profits are also forecasted, providing a definite objective for each division of the business. The cost accountant prepares a monthly statement showing the actual profits in comparison with the forecast and an analysis of the causes of any variation from the forecast, showing how much of the variation was due to loss of sales; how much to cuts in sales prices; how much to sales expenses; and how much to manufacturing costs, etc. Supporting this are detailed statements which

analyze the profit losses in complete detail, showing by districts and salesmen the effect of failure to realize standards and providing similar detailed information regarding factory inefficiencies.

George Horace Lorimer, in his *More Letters from a Self-Made Merchant to His Son*, strikes the keynote of the cost accountant's problem when he writes:

In the first place, you don't need to bother very much about the things that are going all right, except to try and make them go a little better; but you want to spend your time smelling out the things which are going all wrong and laboring with them till you've persuaded them to lead a better life.

When the above was written cost accounting was not developed to a point where it would do the "smelling out the things which are going wrong," but the modern cost system performs this function for the manufacturer, leaving him free to devote his time exclusively to the business of correcting defects disclosed to him by his cost system.

From all of the above it will be obvious that the cost accountant is rapidly becoming an important factor in industry and his development in the last few years from the status of a clerk to his present standing is largely due to that excellent organization, the National Association of Cost Accountants. The remarkable growth of this association is evidence of the great interest which is being taken in cost accounting, and one of its most notable achievements is its accomplishment in the bridging of the gap between the engineer and the accountant. Recently four engineering societies and the National Association of Cost Accountants organized joint sessions for the discussion of the subject of "Budgeting for Business Control," an exceedingly happy omen for the future of cost accounting as an aid to management.

The Development of Industrial Budgeting

By HOWARD COONLEY

President, Walworth Manufacturing Company, Boston, Mass.

ALTHOUGH the first evidences of science in business came more than a score of years ago in production activities, it has been only within the last decade that scientific methods have been applied to all phases of commercial and industrial activity. War necessities not only showed the need of well-defined business planning, but forced its development. And it was due to scientific planning that industry was able to meet the war needs. Since the signing of the Armistice, intelligent men have recognized the fact that the day is coming when there will be a profession of business just as there is a profession of law and medicine, and that the young men not trained to an understanding of the science of business will not qualify in the future for high executive positions.

Business will be done on a closer margin of profit and by larger individual units. The predominance of the small individual producer is past and modern competition forces the efficiency and economies possible only to large organizations with far-spread merchandising units and with plants located so as to obtain the lowest cost of raw materials and labor and the most economical distribution of each separate line of product. Such far-flung activities require centralized control of the highest type,—a control in which foresight and wisdom make up for the lack of that natural leadership which the individual of the past possessed through his constant contact with the smaller group under him. The great advantage which the executive of the past had through the loyalty brought about by daily contact with

his workman, and through the constant watchfulness of his expert eye as to actual accomplishment, must now be replaced by other qualities.

The modern administrator must to a large extent pass down the inspiration of his leadership to the individual workers: first, through conferences with the local executives supplemented by occasional trips through the offices and plants; and second and far more important, by his ability to visualize every form of activity of his business and, through effective planning, to gain the respect and confidence of his organization, through recognition of his ability to foresee his problems and to meet them with an intelligence that was impossible in the past. It is to gain this second advantage that industrial administrators have been led to install what is known as "Budgetary Control."

To many the term suggests red tape, excessive overhead expense and a waste of effort out of all proportion to the value to be derived. Certainly, if a budget be extended to involve detail comparable with that necessary for governmental control of expenditure, few industrial administrators would consider it seriously. But, fortunately, the idea itself without its extended refinements may be utilized. Neither excessive time nor unwarranted expense is necessarily involved in assuring a very definite control. And such control brings a return far greater than can be measured in money alone.

In any well regulated business the head of each department is supposed to review at least once a month his current status. The time required to sub-

mit estimates under a budgetary system is only slightly greater than that required for such rather desultory review. Yet the results due to increased accuracy and definitized methods of procedure are incalculably greater. After all, such a system merely provides glasses through which the estimator may focus his eyes upon his problem, and thereby furnish his chief constant evidence of his ability and grasp of his job,—an evidence which it is no longer possible to give by personal contacts.

THE PROBLEMS OF BUSINESS GROWTH

Twelve years ago when I became connected with the Walworth Manufacturing Company they had a single plant in Massachusetts,—one that was turning out a product largely for the New England and Atlantic Coast trade. Their sales amounted normally to something like two million dollars. Two and a half million was the largest year's business they had ever done. Today our company is reaching all the markets of the world and our sales approach twenty million dollars annually. This has required not only an extension of our merchandising and manufacturing facilities, but a large increase in our lines of product. Our present list of pipe fittings, valves and tools made of cast iron, malleable iron, brass and steel requires us to have ready for shipment at any time something over twenty-three thousand different finished articles. In terms of completed parts, this means several times that number.

Our material goes to the building trades, to manufacturing plants, to the railroads, shipbuilders, oil producers,—in fact, to every field of activity in large quantity. Although new construction of buildings and equipment of all kinds plays a large part in our de-

mand, by far the greatest tonnage is used in repair work and, therefore, we are usually subject to the necessities of quick delivery. We distribute this product (approximately fifty thousand tons of finished material per year) through eleven of our own branches located in the largest distributing centers, and through large jobbing and manufacturing customers.

We now have two factories, one in South Boston which produces under normal conditions something over one thousand tons of finished goods a month, and in Kewanee, Illinois, a second and larger unit producing normally something over three thousand tons monthly.

This increase of approximately one thousand per cent in ten years, desirable as it may appear, has not been unattended by disadvantages and problems. Personal contact between the members of the business family is now difficult and infrequent. Only once a year is it practicable to bring all the sales managers together, and rarely indeed is it possible for a subordinate executive or a salesman in the Far West to visit eastern headquarters or the factories in Illinois and Massachusetts. Here was a handicap with which all concerns doing a nation-wide business are familiar.

Our growth had brought us many other problems and perplexities, not the least of which had been the great question of the co-ordination of production with sales, and the provision of adequate finances to keep us liquid. Necessity had forced us to ask ourselves the question, "How can we find a method of more definitely estimating our sales and, therefore, more intelligently producing our goods so that they will be ready when our trade demands them?" Like most other manufacturers we had been accustomed to produce as the orders came in. That

meant a scramble from short time to overtime; a rush to hire more people, teach them their jobs, and before we got under way we would find ourselves two or three months behind our orders. Then the tide having turned, we would find ourselves glutted with inventory and would have to send our trained experts out into the world to seek other work.

We knew, of course, that this method was unscientific and evidenced that we were not giving regular employment to our workers, were not producing economically or giving our stockholders the return they might reasonably expect on their investment. So with a definite recognition of our weaknesses and a firm conviction that there was a way out, we began groping about, somewhat in the dark at first, for some method of estimating our sales so that we could meet our problems as they came to us and not as they passed us by.

When we began our study we were astounded to find that our line had developed to the extent of twenty-three thousand different finished articles. That seemed a staggering mass of items to control, and indicated that before we could begin operations under the proposed plan, it would be necessary to prepare such elaborate records of past performances that my associates were inclined to feel that the "game was not worth the candle." Some were even convinced that it was an impossibility.

Yet without a knowledge of the sales of each item over a long period of years, so as to see whether we could establish a percentage relationship in the demand for these items, as well as to find their seasonal and long-time fluctuations, any intelligent forecasting was impossible. The value of the results obtained was naturally in exact proportion to their accuracy. Fortunately, our first experimental studies convinced us that such a definite rela-

tionship existed and, therefore, our courage to go further was stimulated.

THE FIELD FOR THE BUDGET

This initial study occupied many months of time. But we did not have to await its completion before we could obtain benefits from the knowledge it gave us. At once our attention was focussed on examples of over- and under-production which could be corrected, and so all those who came in contact with the early study began to be inspired with its possibilities and to enter with enthusiasm our field of research. The final results were satisfying beyond our fondest hope. Our cyclical and season trends were well defined. Search for barometers of comparison was fruitful. And even before our preliminary records were completed we had begun to use these barometers to guide us in our planning.

One of the great measures of business efficiency is *Service*. Another is *Economy*. Service requires that there should be available for the customer the right goods at the right time. Economy calls for saving of material, of labor and of finances. An overabundance of working capital is by no means desirable. It is of just as great importance to make the stockholders' money work hard as it is to obtain maximum production from employees. The financing of peak-load inventories may better be done through bank loans than by adding to permanent working capital. A high turnover of money increases the possibility of profits and keys up the organization.

As these possibilities developed one by one during our period of research, it can easily be imagined that our organization was inspired with possibilities of control never before deemed possible, and was ready when the plan had been completed to take hold of it with enthusiasm.

Goals of budgetary control are threefold:

(1) As a sales guide to provide an accurate forecasting of customer demand and to use that forecasting not only as a basis for production, but also as a foundation for a merchandising campaign.

(2) As a production guide—

a. To provide an intelligent program of manufacture which will insure a supply of merchandise in advance of demand, while keeping inventories in proportion to that demand.

b. To prevent fluctuations of employment which tend to decrease efficiency and contentment.

c. To arrange for maximum production in the season when efficiency is at its highest point and the labor supply is ample.

(3) As a financial guide—

a. To estimate the amount of working capital that is permanently required by the business.

b. To indicate the amount of outside money that should be arranged for to take care of peak investment.

To assure proper budgetary procedure there are also three fundamental necessities:

(1) That there be a sound plan of organization with the authorities and responsibilities of organization well-defined and adequately maintained.

(2) That the records be so established as to place definite responsibility on each unit of organization.

(3) That the business budget itself be a forecast of future accounts in terms of organization responsibility.

OUR BUSINESS ORGANIZATION

Definite control is possible only through the medium of a sound organization. Therefore a discussion of our experiences in attempting to adjust our business so as to satisfy the fundamen-

tal requirements of a budgetary system is necessary.

Careful consideration of the first requirement of budgetary control will make it evident that business organization demands, first, policy decisions; then, definite execution through effective channels; and, last, a staff provision, for abstracting and digesting information vital to both policy decision and executive action. It is essential that the policy-making be separated from the execution and that the channels provided for execution under the policy decisions there should be gradations of authority and of responsibility.

The president naturally becomes the vehicle for interpreting the directors' policies and for formulating the concrete instructions which must be transmitted to executives of the second rank, who in turn are burdened with their actual execution. There should be a limited number of these second rank officials reporting to the president, each becoming the focal point of all activities covering a single phase of the field of operation. The most typical of such fields are sales, production and finance. There cannot be a miscellaneous delegation of authority to too many assistants reporting directly to the president, for such a wide assortment of delegated duties means dissipation rather than organization of energy and the president would, himself, be forced to keep in touch with all the details in order to assure the necessary balance.

On the other hand, these second-grade men or "major executives" should each in turn delegate his authority and responsibility to men of third grade, and so on as far as necessity dictates. No control can be possible if there be not a clear line of authority or if there be no definite classification of naturally grouped responsibility. In addition to the activities under the direction of these delegated authorities,

staff activities will be necessary. The purpose of staff activities is the accumulation of the data of control and of independent check-ups of the policy execution.

In the case of our company, the Planning and Statistics Section, whose head is assistant in staff capacity to the prime executive, the president, gathers control data, interprets present operation in all of its general aspects, and forecasts probable future conditions.

When adequate line-up of all the executive functions was first attempted, it was not easy to eliminate overlapping jurisdictions. On the part of the major executives then in charge of the company's activities, there was a natural dislike to have former duties severed. But these prejudices were soon dissipated and an organization chart was built up designating major officers reporting to the president under the titles of vice-president in charge of sales, vice-president in charge of production, vice-president in charge of administration, and (because of the technical nature of our product), one reporting as vice-president in charge of engineering.

Of necessity a classification was agreed upon breaking down the activities of each of these vice-presidents. Under the vice-president in charge of production were placed our two factories, one in the East and one in the Central West. Similarly under the vice-president in charge of sales were concentrated all of our merchandising activities; first, upon the basis of branch distribution to consumers; and, second, upon "large lot" distribution, through sales divisions, to jobbers who in turn sell to the consumer. In the case of each branch or division there are distinct territorial limitations and definite restrictions as to the type of customer sold, so that delegation of authority and responsibility is specific.

ACCOUNTING FOR BUDGETARY PURPOSES

Having provided an organization that can be held accountable, the next requisite is a system of accounting that will hold the organization to its responsibility. Accounts should not be merely a vehicle for providing the general auditor a means of checking results. They should serve a far greater field of usefulness. In budgetary procedure they provide the most powerful medium for giving executives a positive instrument of control.

Accounts must be designed to line up with the organization chart of the company in whose service the budget is to operate. This fundamental is recognized by everyone trained in such matters. Yet we may well suggest caution against attempting to set up a budget until there has been established a classification of sales, of purchases and of production, with identifying account numbers that can be clearly linked up, step by step, with delegated responsibility. For example, until there had been provided for our company a classification of sales by territories, so as to show how much is being distributed individually through the New York, Chicago or any other branch office, no effective budget could be established for each territory. As a natural corollary, there could be little value in any budget making on a territorial basis unless there had been designated "territorial responsibility."

There must also be a classification by kind of product if, as is the case with us, there are so many lines of product that the major executives cannot think in terms of such extended detail. The grouping of product into classes having been determined, this automatically becomes a standard for tracing all movements of the product from the raw material, through work-in-process

to the finished stock; and thence by the medium of "works' charges" to the branch, and from the branch by sales charges to the customer.

In the case of the Walworth Company we found it unwieldly, if not impossible, to account in terms of the twenty-three thousand separate items shown in our catalog, and we therefore grouped together families of items according to the nature of the product. There were developed two "grades" of grouping. The full line of product is first divided into thirteen major groups, each comprising one general type of product; and each of these groups is then subdivided into minor product classes. Yet even this more detailed breakdown is limited to only fifty-six types of product. This product classification, nevertheless, follows through all accounting, so that we may trace the cost and volume changes from the raw materials straight through to the ultimate sale to the customer.

Subsequent study of production and sales by individual item has developed the interesting fact that each item moves in harmony with its line or classification. In other words, usual assortments are nearly always maintained, so that we were able to develop ratios which could be applied to existing "product classes" when interpreting, in terms of items, the significance of product class movements.

Needless to say, no matter how accurate a definition may be shown upon the organization chart or in the accounting classification, no real value will materialize if accounting data are not issued promptly while the information is still fresh. Shortly after the close of every month the executive head of each separate unit (such as a branch, a factory, or a division) is furnished with a complete balance sheet, profit-and-loss statement, detailed expense analysis, and inventory report. In fact we

feel it essential that each manager of a unit which contributes to the success of the company should know promptly how effectively he has accomplished his task. In addition to these auditors' statements, there are compiled by the Planning and Statistics Section for the major executives statistical reports of a preliminary nature (yet essentially correct for all purposes of guidance) upon all phases of the company's activities.

With such an accounting background and with such up-to-the-minute data we are then in a position to talk of constructing budgets, "future accounts" that shall line up adequately for comparison with our present-known records of experience.

BUDGET ESTIMATING

From this point of development there has been a gradual growth toward budget estimating, made possible because of the accumulating records of our past experience in comparable terms. With a growing fund of accurate data, increasing analysis and broader interpretation have become possible. At first each executive was asked simply to estimate along broad lines his expectation for the following month. Since the estimates were necessarily stated in quantity terms, the manager was forced to observe the quantitative records of his unit's performance. This compelled him to consider the probable outcome of his present month's activity and to anticipate to what extent his next month's operation should vary from preceding recorded experiences.

New Englanders have recently been thrilled by the wonders of a total eclipse of the sun. The exact second at which each phase of the phenomenon would take place had been predicted long in advance. It was this foreknowledge that made possible the in-

TABLE I—ESTIMATE OF THE EXPENSE OF NEW YORK BRANCH
FOR MONTH OF APRIL, 1925

No.	ITEM	ACTUAL FOR JAN.	ORIGINAL ESTIMATE		REVISED ESTIMATE	
			Accrued	Disbursed	Accrued	Disbursed
	A	B	C	D	E	F
1	Pay-rolls (Salary Class): Includes the compensation of all personnel in the salary class except those paid from the general office. This class of compensation is chargeable to the (-50), (-52) and (-56) accounts.....	0,000	0,000	0,000	.....	.....
2	Pay-rolls (Wage Class): Includes the compensation of all personnel in the wage class. This class of compensation is chargeable to the (-55) account....	0,000	0,000	0,000	.....	.....
3	Pay-rolls (Commissions): Includes all payments made to any employee for commissions, chargeable to the (-51) account.....	000	000	000	.....	.....
4	Expense Purchases (Paid by Branch): For outside vendors' material or services chargeable to accounts: -60—Repairs and replacements of miscellaneous equipment -67—Donations, etc. -70—Machinery repairs -78—Telephone and telegraph -81—Association memberships -82—Rental -83—Postage -84—Packages, crates -85—Supplies, etc. -86—Fuel -87—Advertising (local) -88—Cartage and freight -90—Travel -91—Power, light, heat -94—Credit and collections -98—Insurance and taxes (If paid by the branch and entirely written off in one month).....	0,000	0,000	0,000	.....	.....
5	Expense Purchases (Paid by General Office): For outside vendors' material or services chargeable to any of accounts listed in "4" above, particularly rent, if any, stationery, etc., contracted for locally but disbursed at the general office.....	0,000	0,000	.....	.....	.....
6	General Office Expense Apportioned.....	000	000	.....	.....	.....
7	Other Inter-Company Expense: Includes all charges to any of the accounts listed in "4" above, due to inter-company purchases of "expense" materials contracted for and stocked by other units.....	000	000	.....	.....	.....
8	Other Inter-Company Service Charges: Includes all charges to any of the accounts listed in "4" above, due to inter-company charges for bookkeeping, collection or other "services" performed by another unit.....	0	0	.....	.....	.....
9	Fixed Charges: Includes monthly apportionments chargeable to the following accounts: -97—Depreciation -98—Insurance and taxes.....	000	0,000	.....	.....	.....
10	Credits to Expense: Includes all credits to expense account rental received, charges for packing, services rendered, etc., which are creditable to the (-99) account.....	00	0	.....	.....	.....
11	Total Branch Expense.....	00,000	00,000	00,000	.....	.....

telligent observation of thousands of people. It is this same type of accurate study that budgetary control provides. Business is made up of a series of similar waves of activity. Future trends can unquestionably be predicted on the basis of past experience. This is the essence of budget making. One of our executives, who admittedly was lukewarm when the idea was first broached, has since said, "I never really knew my job until I had to estimate for the budget."

Of course, our practice is somewhat more elaborate at present than in those early days. Table I is exhibited to show the style of our present budget questionnaires. This particular table happens to deal with the subject of expense incurred under one of the branch managers. But it is typical. It will be observed that each group of activities, requiring a separate estimate, is stated in accounting language familiar

to us and it may be noted that each of the estimated amounts asked for is exactly comparable with groups of items of the expense analysis which the executive receives from the general auditor. As the needs for the master budget require, other questionnaire schedules are sent to each manager. All schedules are sent out on the tenth of the month preceding the period to be estimated and are returned to the Planning and Statistics Section by the twentieth, thus giving time to have the finished report distributed before the new month begins.

When the estimated data is gathered by the Section, it is summarized and analyzed in several ways. Table II suggests how profitably, yet simply, some of the details may be set forth for control purposes. In the left-hand columns averages of known past experience are developed for each of a number of groups of items. Against

TABLE II—DETAIL SUMMARY NEW YORK BRANCH—ANALYSIS OF COMMODITY PURCHASES
FOR MONTH OF APRIL, 1925

	Nov.	Dec.	Jan.	AVERAGE	PER CENT OF SALES		ESTI- MATE BY UNIT	REVISED ESTI- MATE	COM- MENT
					Ave.	Est.			
Out of Stock Sales:									
Owned and consigned pipe	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Other O/S.....	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Total O/S.....	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Purchase Cost of Sales:									
Owned and consigned pipe	00,000	00,000	00,000	00,000	00	..	00,000 ²	.....	.....
Other O/S.....	00,000	00,000	00,000	00,000	00	..	00,000 ²	.....	.....
Total cost O/S.....	00,000	00,000	00,000	00,000	..	..	00,000 ²	.....	.....
Purchases for Stock:									
Owned and consigned pipe	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Other O/V.....	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Walworth I/C.....	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Total purchases for stock	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Direct Shipment Sales:									
From O/V.....	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
From I/C.....	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Total.....	00,000	00,000	00,000	00,000	..	..	00,000 ¹	.....	.....
Cost of D/S Sales:									
Pipe.....	0,000	0,000	0,000	0,000	..	..	0,000 ¹	.....	.....
Other O/V.....	0,000	0,000	0,000	0,000	00	00	0,000 ¹	.....	.....
Walworth I/C.....	00,000	00,000	00,000	00,000	00	00	00,000 ¹	.....	.....
Total cost D/S.....	00,000	00,000	00,000	00,000	00	00	00,000 ¹	.....	.....
Total Purchases Combined.....	000,000	000,000	000,000	000,000	..	..	000,000 ¹	.....	.....
Total Sales.....	000,000	000,000	000,000	000,000	..	..	000,000 ¹	.....	.....

¹ Unit's Own Estimate.

² Inserted by P. and S. Section.

these past performances the proposed estimates are set up for comparison. In the case of "purchase cost of sales" items, which are not estimated directly by the executive, the necessary amounts are derived by using ratios developed from past experience. Purchases for stock may then be compared directly with the purchase cost of sales out-of-stock with an immediate revelation of the extent to which stocks on hand would increase or decrease. If the variation in the size of stocks is justifiable, the estimate may be approved without revision. If the comparison does not show as satisfactory proposed condition, revised amounts may be calculated and the matter will be taken up with the estimator. There is a similar summary covering each phase of activity, and these reports are reviewed by the executive in charge of the estimating official. In this way the reviewing executive may call for a revision by his subordinate if it seems desirable.

Table III shows the final summary or the master budget which is built up directly from these subsidiary reports. In the first three columns this master budget yields a mass picture of the future income and outgo through sales, purchases and payroll. In the last two are shown the immediate income and outgo through the medium of estimated cash receipts and the cash disbursements. Virtually, the sales-purchase comparison reflects the cash situation sixty days hence, whereas the cash columns predict the banking position within a thirty-day period.

It is acknowledged that this form of budget summary does not construct in advance a predetermined profit-and-loss statement. It is our feeling, however, that such a statement would necessitate considerable detail that is not actually warranted. For if the *rates* of activity reflected by this form of bud-

et are properly controlled and balanced, then the greatest possible profit will be assured whether or not the refinements of accounting are insisted upon in formulating contingent estimates of the future.

As already suggested, the greatest value of this type of summary is that it may be broken down again at any point where favorable balance seems threatened. Where there is a suggestion that a "sore spot" may be developing, reference to the subsidiary sheets in that connection will reveal at once the desirable revisions which may be agreed to by the estimator *before* final commitments are entered into.

To restate an earlier thought, the necessity of budget preparation in itself makes the estimator think more deeply into his business and realize more clearly the need of eternal vigilance. Each month he is made to visualize the trend of his unit's activities, and to present to his superior an evidence of his business judgment. In turn that superior is given an opportunity to review his plan and to call for a change if it does not synchronize with the broader company policies. The budget is in no sense a system of spying. Each manager is given ample authority to carry out the plans which he has had a part in formulating. But he realizes that it is essential that he should be guided in handling his section of a complicated piece of machinery, only a portion of which comes within the scope of his vision.

FORECASTING SERVICE FOR CONTROLLING ACTIVITY RATES

It has been intimated in a previous paragraph that when the rates of activity are properly controlled and balanced, profit commensurate with business conditions will result. It must be realized, however, that there could be no adequate gauging and controlling if the

TABLE III—FINAL COMPILATION OF COMPLETE BUDGET FOR BUSINESS OPERATION 1
(Even Dollars)
Walworth Manufacturing Company and Subsidiaries
For Month of April, 1926

COLUMN LETTER.....	(A) BILLINGS	(B) PURCHASES	(C) PAY-ROLL	(D) INTER-CO. BILLING	(E) INTER-CO. PURCHASES	(F) COMBINED BILLING	(G) COMBINED PURCHASES	(H) CASH RECEIPTS	(I) CASH DISBURSE- MENTS
ITEM									
(1) General office.....	105,000	31,000	43,000	.....	300	.....	74,300	146,000	1,370,000
(2) Eastern division.....	13,000	10,000	9,000	.....	170,000	195,000	189,000	210,000	.....
(3) Boston works.....	560,000	20,000	250,000	500,000	78,000	513,000	585,000	.....	.....
(4) Western division.....	75,000	11,000	12,000	.....	530,000	560,000	543,000	880,000	875,000
(5) Kenawee works.....	240,000	440,000	380,000	910,000	53,000	985,000	875,000	.....	.....
(6) Boston branch.....	250,000	167,000	18,000	9,000	120,000	249,000	305,000	240,000	65,000
(7) New York.....	210,000	100,000	22,000	.....	150,000	250,200	272,000	240,000	46,000
(8) Chicago.....	135,000	88,000	19,000	5,000	98,000	215,000	202,000	196,000	97,000
(9) Seattle.....	195,000	132,000	12,000	3,300	138,200	195,500	157,000	158,000	70,000
(10) Philadelphia.....	165,000	100,000	11,000	500	67,000	185,500	178,000	188,000	143,000
(11) Walworth Oregon Co.....	120,000	134,000	11,000	2,400	11,000	167,400	156,000	140,000	85,000
(12) Buffalo branch.....	1,315,000	116,000	10,000	2,000	9,000	122,000	135,000	140,000	506,000
(13) Total branches.....	1,315,000	837,000	103,000	22,400	468,000	1,337,400	1,408,000	1,327,000	155,000
(14) Walworth International Co.....	195,000	48,000	11,000	.....	150,000	195,000	209,000	180,000	70,000
(15) Walworth Ohio Co.....	275,000	125,000	25,000	1,000	175,000	276,000	325,000	250,000	75,000
(16) Walworth Muns. Co.....	175,000	140,000	10,000	2,500	10,000	177,500	160,000	190,000	3,051,000
(17) Total.....	2,803,000	1,902,000	843,000	1,435,900	1,694,300	4,238,900	4,369,300	3,183,000	470,000
(18) Total pay-roll.....	.....	843,000	.....	.....	.....	.....	.....	470,000	2,581,000
(19) Inter-company.....	2,803,000	2,745,000	.....	.....	.....	.....	.....	2,713,000	.....
(20) Total.....	.....	164,000	.....	.....	.....	.....	.....	.....	.....
(21) Financial expense.....	2,803,000	2,909,000	.....	.....	.....	.....	.....	.....	.....
(22) Total.....	.....	2,909,000	.....	.....	.....	.....	.....	.....	.....
(23) Capital and other charges.....	2,803,000	2,909,000	.....	.....	.....	.....	.....	.....	.....
(24) Total.....	2,803,000	2,909,000	.....	.....	.....	.....	.....	.....	.....

\$10,800 for Insurance.

\$11,500 for Branch Extra Purchasing and Deferred Charges.

9,500 for Plumbing Catalog account.

\$162,500 Total of Financial Expense.

None of the figures on the budget indicate the effect of any proposed note transaction.

\$2,500 for Interest on Bonds (book charge only).

26,900 for Interest on Bonds (book charge only).

5,400 for New York Rental (book charge only).

All the figures and their relations as shown are fictitious.

Financial Expense includes:

\$10,000 for Special Funds.

\$2,500 for Interest on Notes Payable.

26,900 for Interest on Bonds (book charge only).

5,400 for New York Rental (book charge only).

first intimations of developing unbalance were received from the monthly budget. Many phases of the business require long-range decision in order to assure effective results. In fact, the quantity of product to be started on its ninety-day process through our shop must be determined many weeks before customers' orders are actually received. Sales quotas, therefore, must be established far in advance. It is upon the basis of a full year's estimated sales quota that the Walworth Company determines not only its production and purchase program, but also establishes its appropriations for plant improvement and extension as well as for advertising and for organization changes. To make such a plan effectively admittedly requires the ability to forecast the future in specific terms applicable to the individual business.

The theory of cycles has become too well established to require discussion. Suffice it to say that sound forecasting requires thorough knowledge of cycle movements. Fortunately, the course of business is not haphazard. Research has determined that as far back as statistics are available, the rises and falls have been recurrent and regular; moreover, that when the ebb begins or the rising tide sets in, certain fundamental conditions are always present.

We are beginning to recognize that the flow of business, whether upward or downward, is controlled by certain basic factors; the yield of stocks as reflected in their selling prices; the status of supply and demand as suggested by commodity prices; the adequacy of the money supply as measured by interest rates; the volume of trade, and so on. For an accurate analysis of these business-cycle activities we have learned that the method most successfully employed is termed "correlation."

Briefly, the term "correlation" implies not only that all activities,—polit-

ical, industrial or personal, and national, local or individual,—pursue their respective courses in recurring sequences of ups and downs, but also that these respective fluctuations can be reasonably well measured and compared with one another. Further than this, the term indicates that the rise and fall of any business as an individual economic unit may be found to have a definite relation to the rise and fall of some other closely allied economic unit, or even to the rise and fall of the nation's industrial activity as a whole.

A study of the term "correlation" instilled in us the natural desire to ask these questions:

1. Does our business rise or fall in consistent sequences over a period of time?
2. Do the various activities of our business fluctuate in harmony with our business as a whole?
3. Do the changes in our business resemble those of general business, or of other closely allied business?
4. If our business does show such synchronized fluctuation, then how many months ahead of, or after other business? And, finally,
5. To what relative extent does it rise and fall?

Our Planning and Statistics Section undertook an exhaustive study of past performances in manufacturing and sales activities and from these carefully gathered records prepared graphic charts depicting the actual rise and fall of our total business over a term of years. This study revealed many violent fluctuations, but at the same time disclosed that these were due to abnormal influences peculiar to the industry or to the company. An increase in manufacturing facilities, the addition of a branch to the selling organization, or an added line of manufactured products were identified as the direct cause of each such fluctuation.

The really important fact disclosed was this: That the business, in its normal development,—that is, the volume changes from month to month not directly due to or influenced by seasonal conditions peculiar to the industry,—followed in an almost parallel line the rise and fall of general business.

From this type of study, and by means of accepted statistical formulae, we developed current forecasts outlining probable activity in many phases of the business. Our forecasting technique is but a specialized extension of the budget idea and is executed by the Planning and Statistics Section. The principle, however, is essentially the same as that which underlies all other budget activities. An understanding of past habits is the best guide to probable future reactions, unless we consciously and deliberately determine upon objective means for changing those habits. This being granted, the study of our past habits is likely to force us to take such objective steps to change them in cases where faulty practice has obviously persisted. As a consequence, the forecasts which are possible from this sort of study, adjusted to allow for deliberate changes in the probable outcome, are kept constantly revised, not only for a full year ahead, but also quarterly and again monthly to adjust for unexpected developments as they are revealed promptly from time to time by the system of current accounting reports discussed earlier. One of the essentials of sound budgetary control is flexibility,—an eagerness to adapt future plans to the emergencies of the present.

EXAMPLE OF FORECAST APPLICATION

It may be of value in concluding this somewhat haphazard discussion to give a definite illustration of the way in which budget forecasts provide a means of predetermining future action. The

example selected is taken from the field of activity which we consider the most difficult to gauge in advance,—that of inventory planning.

Our business is one in which prompt shipment is essential. Fully eighty percent of our orders are supposed to be shipped "out of stock." It is therefore of the utmost importance that, in order to give our customers good service, we build up large inventories in advance of heavy ordering; and it is equally essential, for the conservation of our resources, that we liquidate our inventory investment in anticipation of slackening demand. Add to this the great benefits that accrue both to the company and its workmen by an evenly balanced production throughout the year, and you have a picture of the advantages that might result from a proper solution of this vital and apparently difficult problem.

Yet solved it has been by means of the budget. Table IV will illustrate the method which we have followed. Anticipation is the keynote of our planning. Given a quarter in which the estimated demand is in excess of average production, we must build up our inventory to take care of this excess before the demand is upon us. And inversely, when a decline of orders is expected, we must be shipping more than we produce some time before the decrease is felt, so that liquidation shall be accomplished during that period of activity and not after it is past.

Desirable inventory is therefore dependent entirely upon the quantity of incoming business. It is not a dead line to be established for good times and bad alike. Granting this, you will realize that the working out of Table IV is not an intricate task, *provided* always we have the ability to estimate correctly the incoming business of the future. With the inventory at the beginning of any period under review

TABLE IV—KEWANEE WORKS WINTER PRODUCTION PROGRAM
(Calculated 10/1/24)

	INVENTORIES				ESTIMATED ORDERS			CONSEQUENT PRODUCTION		ESTI- MATED 4TH QUARTER SHIPMENTS	CONSE- QUENT 1/1/25 INVENTORY
	Actual 1/1/24	Actual 7/31/24	Predicted 10/1/24	Desired 4/1/25	(E) C-D	(F) (Note a)	(G) (Note b)	(H) F+G	(K) H+E	(M) $\frac{K}{2}$	
Product Class A.....	1,622	1,725	1,755	1,825	+ 70	1,420	3,120	4,540	4,610	2,305	2,930
" " B.....	0,000	0,000	0,000	0,000	-0,000	0,000	0,000	0,000	0,000	0,000	0,000
Product Class D.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
Product Class E.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
Product Class F.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
" " H.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
" " K.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
Product Class M.....	0,000	0,000	0,000	0,000	- 0,000	0,000	0,000	0,000	0,000	0,000	0,000
" " R.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
" " S.....	0,000	0,000	0,000	0,000	- 0,000	0,000	0,000	0,000	0,000	0,000	0,000
Product Class U.....	0,000	0,000	0,000	0,000	- 0,000	0,000	0,000	0,000	0,000	0,000	0,000
" " W.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
" " X.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
Total of All Classes Shown....	0,000	0,000	0,000	0,000	-0,000	0,000	0,000	0,000	0,000	0,000	0,000
Total of All Other Classes.....	0,000	0,000	0,000	0,000	+ 0,000	0,000	0,000	0,000	0,000	0,000	0,000
Grand Total.....	0,000	0,000	0,000	0,000	-0,000	0,000	0,000	0,000	0,000	0,000	0,000

Note (a) Figures from Column G of Table I of order forecast.
 Note (b) Figures from Column M of Table I of order forecast.

Note (c) Fourth quarter shipments are estimated equal to fourth quarter orders, minus one-half of December orders, which proportion of December orders is usually "for shipment after January 1st."

accurately known, with the desired inventory at the end of the period established on the basis of future expectancy, the period's production requirements are the predicted incoming orders plus or minus the inventory change ($K = H + E$). Incidentally this table also illustrates the methods employed to equalize production.

RESULTS OF INDUSTRIAL BUDGETARY CONTROL

Of the many benefits to be gained from an industrial budget, unquestionably the most important is in this field of production control. For it is through the regularity of the flow of output that the greatest savings in cost and the maximum contentment of the workmen are gained. Our accumulating experience is proving that budgetary guidance in this field is of inestimable value.

In the final exhibit, Figure 1, are shown three curves. The upper line pictures the erratic flow of incoming orders, which range during boom periods to levels more than twice as high as those of orders received during slack periods. The second line indicates the number of employees making up our organization and is drawn to exactly comparable scale with that of the first curve. During 1919-1920, new workers were hired in numbers increasing almost as sharply as the orders themselves increased. So rapid an expansion of the working force could not provide for adequate training and assimilation of the new workers in the established organization, nor could production be speedily accelerated to make possible immediate shipment of the orders received. Hence, in the third curve we find an extremely high level of unshipped orders in 1920. However, with the constantly declining order rate during 1920-1921, there was no choice but to restrict the number of em-

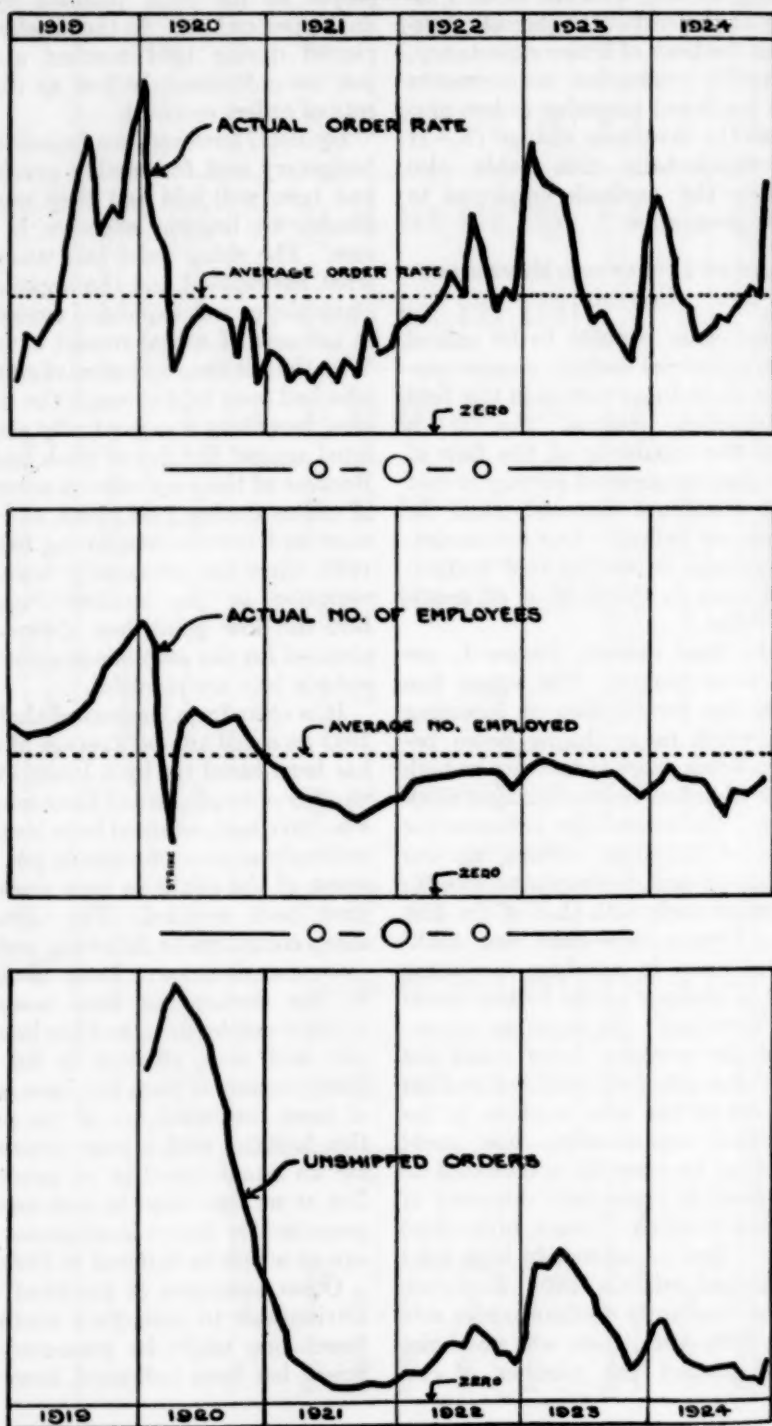
ployes to the point justified by the unshipped orders. So the number employed during 1921 reached a point just as unfortunately low as did the rate of orders received.

By 1921, however, the foundation of budgetary and forecasting procedures had been well laid and they were beginning to become effective in practice. The rising order rate was somewhat anticipated and the organization of employees was expanded accordingly in advance of actual receipt of orders. With the full-time operation of employees who had been held through the depression, inventory was gradually accumulated against the day of peak business. Because of the very uneven movement of orders during 1922, 1923 and 1924, more erratic even than during 1919 and 1920, there has necessarily been some variation in the number employed. But the low point has always been planned for the summer months when outside jobs are plentiful.

It is clear from the record that since 1921 an equal annual average of orders has been cared for by a lesser average number of employees and these employees who have been retained have been more definitely assured of a steady job. The worst of the peaks in rush production have been avoided. The threats of sharp curtailments, following periods of overexpansion, have been dissipated. So the worker has been assured of steadier employment and has been happier and more efficient in his work. The company in turn has been assured of more continued use of the production facilities with a lesser expenditure for an equal quantity of production. Yet at no time has the customer been penalized by delays in shipment to the extent which he suffered in 1920.

Other examples of practical results attributable to budgetary control and forecasting might be presented. Sufficient has been indicated, however, to

FIGURE 1



justify our acceptance of budgetary control as the "compass" of the Walworth Company.

After all, the real purpose of business is service. And there are three groups to whom that service is due,—the stockholders, the employes, and the public represented by the customers. A policy that ignores any one of these parties at interest fails of its purpose. Fortunately, over a period of time what

is wise for one is wise for all. This is an age of keen competition. Science in industry is today just as essential as in any of the so-called professions. And science, after all, is nothing more than the application of the research of the past to guide the action of the future. What truer definition than this could we find for budgetary control? It keeps the brain active, the motion flexible, the eyes always toward the front.

The Analytical Study of Production Jobs

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INDUSTRY progresses in the degree to which it supplants opinion and rule of thumb knowledge with fact and analysis. This is not only very definitely and clearly shown in the significant progress which has resulted from the utilization of science in the solution of many of the technical problems which have confronted industries in conjunction with the better utilization of materials and the improvement and development of processes, but it is also demonstrated remarkably well in the change in the method of attack of management problems which must be evident even to the most casual observer. This change with reference to management problems has taken place within the last fifty years and has had its inception in, and is best demonstrated in, the analytical study of production jobs.

PRIMITIVE JOB STUDIES

When job study was first used, not in its highly developed form as we know it today, but in some elementary form, is not definitely known. It is highly probable that man has always given some thought and attention to the improvement of the work he had to perform to earn a livelihood, for without this it is hard to imagine how he could have made any progress. Fundamentally, there is not a very great deal of difference between the inhabitant of an ancient country centuries ago, who, after years of carrying water from the stream to the point of use, found it easier to hew out a number of logs and use them as pipes to convey the water for him; and the modern job study man who carefully analyzes

the work of the machine operator with the idea of eliminating all waste motion and developing a standard method of performance. In both cases, interest centers around the elimination of waste effort and the improvement of the method of performing the work. The chief difference lies in the method of analysis rather than in the purpose of the analysis. Certainly Egyptologists and Assyriologists, who seem to be able to find an ancient counterpart for most things which we in our modern civilization are prone to consider new, could find numerous examples where ancient people in the construction of their temples and palaces carefully analyzed their work in a way not fundamentally unlike the methods used today.

So also in the days of handicraft production, when the apprentice learned his trade from the master, it is very likely that there was a gradual improvement in the method of performing the work, both as a result of daily contact with and conscious study of it. However, it is very easy here to over-emphasize the actual improvement made under this system of production. One can still find trades where the work today is being performed in substantially the same manner it was performed a century and more ago.

The beginning of the division of labor itself was the result of the casual study of jobs made at a time when the market for goods was increasing and it was seen that the increased production resulting from this division of labor could be sold in the ever-broadening markets of the time. With this division of labor, it was possible to study fur-

ther and in greater detail the resulting jobs, which study developed later into the invention of machinery to perform the work previously performed by hand labor. Adam Smith in his work, *An Inquiry into the Nature and Causes of the Wealth of Nations*, published in 1776, says the following, in Book I, chapter 3, with reference to this point:

" . . . I shall only observe therefore that the invention of all those machines by which labour is so much facilitated and abridged seems to have been originally owing to the division of labour. Men are much more likely to discover easier and readier methods of obtaining any object when the whole attention of their minds is directed toward that single object than when it is dissipated among a great variety of things. But, in consequence of the division of labour, the whole of every man's attention comes naturally to be directed toward some one very simple object. It is naturally to be expected, therefore, that some one or other of those who are employed in each particular branch of labour should soon find out easier and readier methods of performing their own particular work wherever the nature of it admits of such improvement.

A great part of the machines made use of in those manufactures in which labour is most subdivided were originally the invention of common workmen who, being each of them employed in some very simple operation, naturally turned their thoughts toward finding out easier and readier methods of performing it. Whoever has been much accustomed to visit such manufactures must frequently have been shown very pretty machines which were the invention of such workmen in order to facilitate and quicken their own particular part of the work. In the first steam engine, a boy was constantly employed to open and shut alternately the communication between the boiler and the cylinder according as the piston either ascended or descended. One of these boys who loved to play with his companions observed that by tying a string from the handle of the valve

which opened this communication to another part of the machine, the valve would open and shut without his assistance and leave him at liberty to divert himself with his play fellows. One of the greatest improvements that has been made upon this machine since it was first invented was in this manner the discovery of a boy who wanted to save his own labour.

The first evidence we have of the use of the watch in conjunction with the study of jobs is quoted in the work of the British mathematician, Charles Babbage, entitled *The Economy of Machinery and Manufacture*, published in 1832. In this work, Babbage states that as early as 1760, a Frenchman listed the operations in connection with the making of pins and had timed them for the purpose of ascertaining the detailed cost of the pins. The method of making this study and its purpose are quite different from the method and purpose of our modern time studies, and there is no evidence that the watch was again used anywhere for the study of jobs until its use by Frederick W. Taylor at the Midvale Steel Company, Philadelphia, in 1881.

TECHNICAL CONTRIBUTIONS OF TAYLOR

To Frederick W. Taylor belongs the credit for the development of the detailed method of analyzing production jobs which is in use today. The development of this method was not only the beginning of the use of the scientific method in the study of jobs in order to determine the best manner of performance and also the standard time of performance, but it also marks the beginning of the development of a new method of attack of all management problems—the substitution of fact and analysis for guess and opinion. With reference to this statement, Robert Thurston Kent has the follow-

ing to say in a review of "Managements' Handbook," published in *The Mechanical Engineering Magazine* for December, 1924:

The science of management began in the experiments of Taylor to find the answer to the question: "How much work should a man do?" At first regarded as a purely local question relating to the machine shop, it was soon discovered that the principles that have found successful application in the machine shop were of almost universal application in every field of human endeavor.

It is unquestionably true that the early work of Taylor at Midvale Steel Works had far greater significance than even he himself imagined at the time.

Taylor abhorred waste whether that waste was of material, of human effort or of time. As long as there was any kind of waste, he saw in its elimination a duty which he had to perform to his employers, the workers and the community. He was in every sense of the word a conservationist. So it was to be expected, therefore, that when he came into power at the Midvale Steel Works that many of the conditions leading to uneconomic production, which he had noticed as a worker, should come under his scrutiny. He had particularly noticed that because of rate cutting, the piece rates in force at that time did not lead to high production and that not infrequently men worked harder to conceal the amount they could produce than they did in actual production. Taylor's analysis of this situation led him to believe that the fundamental difficulty here lay in the fact that neither the management nor the men knew of what a fair day's work consisted. The management continually set rates which resulted in the worker earning more wages than the management considered desirable; consequently, the rates were cut. After the piece rates were cut several times,

the workers naturally limited or "pegged" their production at a point where their total earnings would not exceed what they believed the management was willing to have them earn. This "pegging" of production resulted in the limiting of the output of the machine shop, of which Taylor was foreman, and prevented him from carrying out what he considered to be the purpose of such a shop, namely, "removing metal from forgings and castings in the quickest time."¹

TIME STUDIES

To one with Taylor's trend of mind, the only natural thing to do in a situation like this was to find out definitely the facts of the matter by means of a study with the stop watch. This Taylor immediately proceeded to do, although unmindful of all the difficult problems he would have to encounter in making such a study. One of these problems, the finding of some quick, accurate and practical means of determining the proper speed and feed of the machine, was not satisfactorily solved until Carl G. Barth, years later at the Bethlehem Steel Works, worked up a slide rule for this purpose.

Determining a fair day's work and setting the proper rate for a job consists in more than merely ascertaining the over-all time of a particular piece of work. To set a fair rate on a job, it is first necessary to be assured that the conditions under which it is being performed and the method of performance followed are standard. No one knew this better than Taylor, and he therefore set about establishing the standards of machinery, equipment, tools, etc., and only after establishing these standards did he time a job for rate setting purposes.

¹ On the "Art of Cutting Metals," address before American Society Mechanical Engineers, at New York Meeting, December, 1906.

The most effective way of studying a job, both for the purposes of standardization and for rate setting purposes is to analyze or break it up into its elements or component parts and carefully and critically study each of these elements for the purpose of ascertaining its necessity and if necessary the quickest and best method of performing it. This involves a study of the machine elements as well as the hand elements. The stop watch aids in determining which elements are being performed under un-standard conditions, because it shows up the differences in the length of time it takes to perform an individual element. When the time for a given element varies considerably, it is an indication that conditions under which that element is being performed are not standard. By comparing the time it takes to perform an element when it is performed in two different ways, it shows which method is quicker. Thus, by this stop watch analysis, we determine the best method of performing each element of a piece of work, and by adding the selected times for each element and adding thereto certain allowances, we obtain a means of determining what a fair day's work actually is, and the results we obtain can be used successfully in rate setting.

The outstanding feature of job study is its careful analysis of the job into its elements or component parts and a careful and critical study of each of these elements, the job study observer having foremost in his mind the improvement of the job wherever possible.

After carefully studying the job and determining the best method to be followed in its performance, this method and the time of all the elements of which it is composed is carefully and in detail set forth upon an instruction card. These instruction cards are given to the worker and are the means

of assuring that the correct method will be followed by him for any given job. If for some reason the method set forth is not understood by the worker, he is carefully instructed in it. If the job is one that is standard and the worker devotes his entire time repeating it day in and day out, the instruction card will probably not be used after the method has been learned by the worker. However, in a shop manufacturing a diverse line of product the worker will continually be referring to his instruction card.

One of the most encouraging signs of the times is the changing attitude of labor to time study. At one time its worst enemy and probably the biggest single force in preventing its continued use in the government arsenals, labor is slowly, very slowly, coming to the point of seeing the economic advantages of such studies to itself, to the community and to the employer. Unquestionably much of the original objection to it was on the ground of the abuse of time study by the employers, rather than against its legitimate use. As establishments take greater care in making these studies and demonstrate to labor their fairmindedness and honesty in setting rates and maintaining them, this old prejudice on the part of labor will disappear faster.

In no consideration of job study would it be proper to fail to mention the careful and valuable work performed in this field by the late Frank B. Gilbreth and by L. M. Gilbreth. Their work in the field of motion study and the determination of *the one best method to do work* and their analysis of fundamental elements as set forth in their writings and as practiced by them in their capacity as consultants, is well worth studying.

Today, the analytical study of production jobs, which was gradually

developed over a long period of time and which was given a tremendous impetus by the work of Taylor, has found its way into many establishments and has proved itself of immense value when carefully carried out. Its use is not limited to the machine shop, as was first supposed by many, but the paper mill, the textile mill, the office are, and any line of business is,

in a position to use it to great advantage. It is a means of increasing production because of the improved method of performing work. Human effort is conserved and waste eliminated, and by using it as a means of setting rates which are guaranteed not to be cut by the management, it enables the management to offer the worker an incentive to turn out higher production.

Control of Production Operations Through Scientific Planning

By H. S. PERSON

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CONTROL is inherent in production and is therefore not something new in industry, but the conditions of control have changed with changes in the nature of industry. The evolution from household-handicraft to factory industry a century ago, and from small-scale to large-scale factory industry, which began in the United States some forty years ago, brought about in the two instances complications in the conditions of control which profoundly affected the problem. In modern large-scale factory industry, division of labor is extreme and precise co-ordination of individual operations of critical importance. In a medium-sized enterprise the products of the individual operations of a thousand workers on any particular day must match each other, and the products of the operations of the thousand workers on any one day must match those of the same or another thousand workers on the next and succeeding days. Otherwise the products of a large proportion of the operations may not only fail to have value but will be a cost to be deducted from those products which chance to have value. Under division of labor *control is the crux of the production problem.*

A control which co-ordinates and gives value to efforts which are separate in space and time is possible only through planning. A plan consists of specifications concerning the nature, direction and time of individual acts so related that their results will merge into an integral composite whole. The choice is between planning and chance. There is no middle ground. If a thousand workers were permitted to

perform their several acts without the control of a plan, by chance there would eventually result some parts which would fit into and create a whole, but at a tremendous waste of parts which would not fit. There would be waste of investment in plant, equipment and materials, of directing and supervising labor, and particularly of labor applied directly to the processing on individual parts. In competitive industry the avoidance of such wastes is a condition of survival. Control through planning is the only way of avoiding waste. *Planning is the crux of the control problem.*

But planning is impossible if the factors involved are unstable. A number of gentlemen may agree to meet for conference at a certain club at four o'clock tomorrow afternoon. Carrying out the plan is impossible—in fact there is no plan—if there is not an understood system of reckoning time based on unvarying natural law, accurate watches, and a club location which is the same tomorrow at four o'clock as it is today, if the gentlemen who agree to meet forget the agreement, and if numerous other facts are not stable. Likewise, a superintendent of a shop may plan to produce ten thousand typewriters next month, but how many he would produce, or whether he could produce one, would remain until the end of the month a matter of chance if steel turned to iron, black japan turned green, lathes changed to grinding machines, precision tools and drawings ceased to be accurate, and terminology for the conveying of information constantly changed. I cite ridiculously

obvious conditions of stability to establish a principle.

Under conditions of competition a waste of 10 or 15 per cent of labor-time and of machine-time may mean failure, and such a degree of waste may be caused by the combination of less obvious variables: variables pertaining to quantity of materials; arrival of materials at machines; machine conditions which slow up processing, and so on. Planning is impossible if there is too much of the unexpected; is but a gesture if chance remains as a considerable factor. At the best under such conditions it can be but a petty, last-minute affair. *The elimination of variables is the crux of the planning problem.*

Therefore, if, under division of labor, control be essential to production, if planning be essential to control, and if elimination of variables be essential to planning, then elimination of variables is the critical problem in production.

It is at this point that science has come for the second time to the aid of industry. It came to the aid of industry first when it discovered laws of the physical sciences and invented means of utilizing these laws in industrial processes and equipment. It has come to the aid of industry a second time by providing methods for investigation of problems of management, and particularly by discovering means for elimination to a very considerable degree of waste-causing instability in the factors with which management is concerned.

ORIGIN OF MODERN PLANNING METHODS

It was Frederick W. Taylor whom fate chose to be the genius to direct our attention to the utilization of science in this second manner. Shortly after serving his apprenticeship as pattern-maker and machinist he was appointed gang boss over a group of machines in

the shops of the Midvale Steel Works and started in to get production from a group of mature and hardened workers—this was 1880 and the steel industry. He began by imitating the customary method of foremanship: arbitrary exercise of power implied in the word "boss"—power exercised to cover lack of exact knowledge—and this resulted in a fight with the men. He won out, but the victory gave him no satisfaction. He became bitter against the customary methods of foremanship, and he made up his mind to either get out or find some remedy for this unbearable condition.¹

He did not get out; a scientific temperament came to his rescue. He analyzed the problem and decided that the root of the trouble was workers' lack of confidence in management's knowledge of its task. Facts should replace guess and hunch and arbitrary orders. His first step—taken without the knowledge of his superiors—consisted in establishing what amounted to a laboratory. He withdrew a man and a machine from regular production, got a lot of scrap metal which happened to be at hand, and went to work cutting metal just for the purpose of securing data to be analyzed. Variables were noted and controlled;—this tension of belt and that tension, this adjustment of machine feeds and speeds and that adjustment, this shape and sharpness of tool and that shape and sharpness, so on in infinite controlled variety, and careful records were kept and analyzed. In an incredibly short time Taylor discovered that, by standardizing all the best unit variables and organizing them into an integral whole, the production of any operation could be increased several times without extra effort on the part of workers, and what is more significant, *could be depended upon.* In its far-reaching consequences

¹ Copley, *Frederick W. Taylor*, Vol. I, p. 5.

it was a momentous discovery for industry. Most fundamental of all from our perspective of today, *the value—immediate and practical—of the scientific method in solving problems of management was demonstrated.*

His second step consisted in devising a method of utilizing these discoveries throughout the shop. As a matter of common sense it was obvious to young Taylor that utilization involved the following: making conditions developed at the experimental machine standard for all machines; careful maintenance of the standard conditions; complete understanding by all concerned through general and special instructions; current records of performance to discover and correct promptly lapses in standard conditions and in understanding of instructions; a sharing of the increased productivity through higher wages to serve as one incentive for learning and maintaining a new and more complicated type of co-operative effort.

From the point of view of later development to meet more complicated situations than existed at Midvale, standardization involves the following, all standards being the result of painstaking research and experiment:

(1) *Product*: Uses, varieties, interchangeability of parts, materials of which made.

(2) *Materials*: Standardization results from standardization of product.

(3) *Plant*. In new construction the adaptation of the plant to the processing requirements of the business.

(4) *Machines*: Kinds, uses, adjustments for particular purposes.

(5) *Tools*: Kinds, uses, characteristics for particular purposes.

(6) *Workers*: Relating of workers to operations through job analysis and the analysis and classification of workers as to physical and temperamental characteristics and acquired skill.

(7) *Methods*: Not so much attention given directly to the workers' motions as to

conditions which bring economy of motions automatically; clear instructions concerning what is to be done; materials and tools at hand and conveniently located; finished product got out of the way; machines kept in repair.

(8) *Times*: Other standards having been established, a standard times for operations may be determined which are agreeable to workers concerned.

(9) *Rates*: Given dependable standard times, a basis is established for agreement upon standard rates.

(10) *Instructions*: Understanding being essential to co-operative effort, all standards are recorded and the records made available to those concerned.

The maintenance of standards is assured through inspection of various kinds:

(1) *Machines and tools* are systematically inspected and kept in the conditions adopted as standard.

(2) *Materials* are inspected on receipt to determine conformity to specifications based upon standards.

(3) *Products*—both unit and assembled—are inspected as to conformity to standards of design, workmanship and other aspects of quality.

(4) *Performance records* are constantly inspected to discover deteriorations in standards which have escaped other forms of inspection, for a decline in a worker's output is in most instances due to causes not under the control of the worker, to deteriorations of standards which the worker has a right to assume as maintained.

The third step consisted in Taylor's taking advantage of the possibilities of planning which standardization offered. Common sense told him that standard conditions permitting measurable results from measurable efforts would make planning possible to a degree so much greater than had previously been realized as to make it essentially a new thing in management. Logically and essentially this step was taken at Midvale, but it was not taken in a significant way until Taylor went to Bethle-

hem, where he had to supervise a machine shop half a mile long which turned out a great variety of products.

At Midvale just as fast as Taylor effected standardization and thereby established conditions he could count upon, he gave more attention to laying out work in advance. Standard conditions making it possible to compute the relations of effort and result with reasonable accuracy, it was no longer necessary to wait until the last minute to know when a job would be off a machine and what job could be done next. Preparation for one job could be begun before the other was off the machine. He began to lay out jobs for machines days in advance. This made possible the elimination of much idle time between jobs.

But at Midvale the variety of operations was not great and in general they were of such a nature that machines were busy upon one job for many hours at a time. So such planning as was done, was done by Taylor himself as foreman. It was just an increment added to his foreman's task, and was not so outstanding as to call for special attention. At that time the desirability of functionalization did not occur to him.

In the big machine shop at Bethlehem (1898-1901) the situation was a much more complicated one; there was a greater variety and volume of products, a greater number and variety of machines, a greater number of workers of a greater range of capacities, and necessarily a less intimate contact with each. On the one hand he had to extend his system of determining, establishing and maintaining standards to make it more resistant to accident. On the other hand he had to develop for the first time a real system of getting the best out of standardization, of putting work through in accordance with predetermined plans and sched-

ules.² This led to division of responsibility along functional lines and the establishment of the planning room.

Taylor's analytic mind told him that determining *what* is to be done, *when* it should be done and *how* it should be done, constitute one class of functions, the material of performance being records; and that doing the things constitutes another class of functions, the material of performance being craft skill, equipment and materials. *What* is determined by the orders which come in or by a plan of manufacture to stock. *When* is determined by the records of assignment of work to machines, embracing also information as to when machines will be freed for new operations. *How* is determined by the records of investigators and experimenters, expressed in instructions relating to standard conditions, standard set-up of machines, standard materials and standard times. So Taylor withdrew certain of his foremen from supervision of work at machines, located them in a corner of the shop partitioned off for the purpose of quiet and cleanliness and systematic preservation of papers, and set them to analyzing orders and work. As time came for a planned job to go on a machine, by written orders materials were got to the machine and instructions were sent to the shop foremen and workers concerned. The planning room group also was given responsibility for the establishment and maintenance of standards and for inspection of performance. The

² What this has come to mean is indicated by the following facts: On December 19, 1924, The Holt Manufacturing Company, Peoria, Ill., had maintained for 789 consecutive working days an exactly scheduled production, schedules being made five months in advance. For a period of over two years, each day delivered a product scheduled five months earlier. This involved scheduling and keeping on schedule over 8,000,000 machine operations. *Bulletin of the Taylor Society*, December, 1924, p. 260.

foremen who remained out in the shop supervising operations, having had responsibility for planning transferred from their jurisdiction, now concentrated upon methods of performance and automatically became essentially teachers. The functional foremanship organization which Taylor came to recommend as standard for a machine shop was, utilizing his original terminology, as follows:

In the Planning Room:

(1) *Production Clerk*: General supervision; concerned with *what and when* in general, and with exceptional situations.

(2) *Route Clerk*: Analyses of an order with respect to the sequence of unit operations and to the *how* of performance.

(3) *Methods, Time and Rate Clerks*: Concerned with investigation and determination of *how, in what time and wage rates* with respect to new operations.

(4) *Order-of-work Clerk*: Concerned with *when* in detail, issuing unit jobs to machines in accordance with time schedule determined by route clerk.

(5) *Progress Record and Cost Clerk*: Concerned with current reports of performance, (a) to discover what is not going in accordance with calculations, and (b) to analyze and record costs.

In the Shop:

(1) *Gang Boss*: Concerned with general supervision—receipt of instructions; materials; emergency situations.

(2) *Speed Boss*: Concerned with correct setting up of machine, in accordance with instructions, at the beginning of an operation.

(3) *Inspector*: Concerned with inspection of first piece of a lot to determine whether the operator has started according to specifications; also with inspection of all pieces after the work on a lot is completed.

(4) *Disciplinarian*: Concerned with settlement of disputes—the original functionalized personnel manager.

The outstanding characteristics of the Taylor method are, therefore:

First, investigation of each management problem in a genuinely scientific

manner and establishment of a factual basis which eliminates guess.

Second, the elimination of chance by the establishment and maintenance of standards which permit calculable efforts and results.

Third, on the basis of conditions which permit calculation of results, careful planning of effort with respect to desired results.

So great generally are the wastes of guess and of faulty co-ordination, management in accordance with this system more than doubles the productivity of a given aggregate of effort of people working together under division of labor.

EXTENSION OF SCOPE OF PLANNING

Taylor focused most of his efforts on the application of scientific methods to the management of the shop. He believed he would be rendering the largest service to industry by intensive work in a restricted section of the management area. Furthermore, shop management—production—was in his day the important problem; industry was still on its long upward swing and in a sellers' market. Critical problems of marketing and of labor relations had not yet come to the fore. But he knew that these areas of management are important and would some day assume a more critical aspect. It was his view that scientific methods would be applicable to these phases of management, but that it was for others to extend the methods to these fields. He even foresaw the importance of a science of psychology to management, for fifteen years ago he wrote—while psychology was still in its pioneer stage and before it had received any attention whatsoever from industry—

There is another type of scientific investigation which has been referred to several

times in this paper, and which should receive special attention, namely, the accurate study of the motives which influence men.³

Others have extended the application of the scientific method in management and today, under the stimulus of conditions of a buyers' market, this method is being applied to management of marketing, as is explained in other papers in this volume, and, stimulated by critical problems of human relations in industry, conduct is receiving intensive and scientific investigation.

I refer to the extension of the scientific method to these other fields, although only parenthetically, for the reason that it is of significance to planning in production control. The recent experiences of production managers on a buyer's market have taught them that the range of variables which affect production planning is much wider than had been at first realized, and that the elimination, by scientific understanding, of certain variables in selling and in human conduct in co-operative relations is essential to highly developed and precise planning in the production processes. Of all variables that which is most disturbing to precise planning in production is irregularity of orders. Of course individual operations, considered as things in themselves, can be planned and executed precisely irrespective of the quantity and flow of orders. But the work of a shop as a whole is upset and cost calculations put awry, on the one hand by a congestion of orders which compels overtime work, and on the other hand by a scarcity of orders which reduces operations below plant capacity and causes idle man- and machine-time. During the past two or three years serious conditions have developed in a number of plants having exceptionally efficient production planning and control methods, simply because the sales de-

partments have not seen the necessity of overcoming, or have not been able to overcome, the increased sales resistance and have not maintained that quantitative basis of orders to which production facilities have been geared and on which control calculations are based. Plants which are suffering from this condition are learning that the economist's definition of production as embracing all activities from the purchase of materials to the delivery of finished product to consumer, is a truer one than the conventional manager's definition which limits production to mechanical processing.

IMPORTANCE OF DATA FILES

The critical unit in the factory planning department is the "data files," which contain the records of methods work, time study and rate setting. Here is the point where science makes contact with planning; where scientific investigation and experiment have deposited the results of its work—formulated standards. Routing, scheduling, inspection of progress and cost analysis have only moderate significance if the data they use in planning or in inspection are not scientifically accurate, *i.e.* do not correspond to stable operating conditions (maintained standards) throughout the plant. The existence of adequate data files is the guarantee that planning and inspection have stable elements to deal with; the absence of adequate data files (except in certain types of enterprise to be considered later) places the whole planning function under suspicion.

One may visit a "model planning room" and be shown neatly arranged desks and apparatus; here the production clerk, there the route clerk and his assistants, there the schedule clerk and his schedule boards (and perhaps pneumatic tubes), and in another place the progress records and the cost clerks.

³ *Principles of Scientific Management*, p. 119.

He may come away impressed. Yet he may have failed to observe the presence of the very thing which makes precise planning possible—data files. If there are data files there is presumably efficient planning, no matter if there is not a bright, airy room, neat desks, up-to-date devices and numerous functionally-labeled clerks. On the other hand, if there are not adequate files, even if there are all the paraphernalia of functional clerks and latest devices, there is presumably not efficient planning. For efficient planning depends upon the use of accurate, minute data concerning standard conditions which have been established and are maintained throughout the plant; not upon clerks and devices.

CLASSIFYING ENTERPRISES AS TO STABILITY CONDITIONS

The control of production through planning is not the same problem for all enterprises. The "natural stability" of conditions in some plants is greater than in others. The more stable the conditions naturally, the simpler the planning organization may be. There is a wide difference between control of operations in a flour mill and control in a machine shop doing a jobbing business.

With respect to the natural stability of conditions and the probable complexity of the planning organization we may conveniently classify enterprises as follows:

(1) Industries with continuous processes: uniform product with uniform specifications; single-purpose machines; uniform operations; simple planning, routing and scheduling. Illustrated by the manufacture of flour, paper and pulp, sugar, pig iron, steel, chemical products.

(2) Industries with non-continuous processes: uniform product with varying specifications; single-purpose machines; uniform operations; moderately complex planning, routing and scheduling. Illustrated by the manufacture of books, automobiles, typewriters, furniture.

(3) Industries with non-continuous processes: varying products with varying specifications; multiple-purpose machines; varying operations; complex planning, routing and scheduling. Illustrated by most jobbing enterprises.

Generally industries of the first group are analytic, *i.e.* take a raw material and break it down into its constituent elements; while generally industries of the second and third groups are synthetic, *i.e.* assemble a whole from individually fabricated parts. There is sometimes an enterprise, however, which varies from the rule for the industry to which it belongs, or which belongs with respect to certain products to one group and with respect to other products to another group. Henry Ford, for instance, through simplicity of specifications and volume of business, has almost, if not quite, transferred automobile manufacture from the second to the first group; in the manufacture of hoisting and conveying machinery the fabrication of standard parts belongs to group two, while the assembly for a particular order belongs to group three; in some chemical plants one class of processes belongs to group one, while another class, the making of compounds, belongs to group two. The first step in the organization of a planning department, therefore, is analysis of the processes and determination of the degree to which stability of conditions is natural or must be created.

The Production Control Method of the Tabor Manufacturing Company

By JOHN W. CARTER

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THE production control system of the Tabor Manufacturing Company had its inception over two decades ago. The complete and unparalleled success with which it has met, and the fact that it was the logical issue of numerous, exhaustive experiments conducted by Frederick W. Taylor, who personally supervised every movement in its installation, together with its orthodoxy, have made it the subject of considerable study by industrialists throughout the world.

This system of control reached its high state of efficiency in the Tabor Company because the operation of it practically approached automaticity. Such a degree of refinement may savor of "red tape," but when the multiplicity of functions in an industry of this type is considered and the exactitude of performance which is necessary to its success, it becomes quite evident that all superfluous effort has been eliminated.

Taylor chose this company as a research laboratory for the purpose of conducting his experiments and proving to the world that his doctrine was sound. The Tabor Company was engaged in the manufacture of molding machines and kindred products, an extremely complex industry inasmuch as it involved assembled products in which the designs were constantly in a state of revision; sales were usually contingent on quick deliveries and the manufacture of most products on any one order was limited to comparatively small quantities.

Such an industry requires constant vigilance to insure raw materials being ordered and available at the proper times, to see that all operations are scheduled for prompt performance and also to preclude any possibility of an excess accumulation of stock both raw and finished which might, in a short time, become obsolescent due to changes in design or to other causes. Conditions of this nature offer perhaps the most severe test to which any form of production control could be subjected. An extremely elaborate system was necessary at the beginning, which has since undergone some changes, but it has fulfilled every requirement exacted of it. Because of its complexity it has been recognized by the exponents of scientific management as basic, and a careful study of it will no doubt reveal many of its virtues.

The Tabor Manufacturing Company handles all its production orders through the medium of a very highly organized planning department, which makes possible the thorough analysis of all jobs that are sent into the shops.

Planning Department. After all correspondence with the salesman or customer and the sale has been consummated, the sales department conveys the necessary information to the planning department in the form of a shipping order which is common to nearly every organization. Theoretically all orders are manufactured for "stock" from whence all shipments are made and if the stock records indicate that the article desired is immediately avail-

able, the procedure is comparatively simple. The necessary requisitions are forwarded by the production manager to the stock and shipping departments, which, after shipment has been made, return these orders for further recording by the planning, engineering, sales and accounting departments and the procedure is completed. Each activity, from the writing of all orders to their final filing, is arranged in its logical sequence, which is clearly indicated on the lower portion of the sheet.

If, however, the article desired is not available for immediate delivery, this shipping order is superseded by a "manufacturing order" and the shipping order is filed in the planning department until such time as is required has elapsed for the manufacture of the article. The manufacturing order, calling for a quantity of articles which is consistent with economical production, is made out in duplicate form, the duplicate being sent to the cost collecting department as formal authority to open an account against the particular order. The original copy is forwarded to the engineering department for the purpose of recording, and if necessary, creating a new design or revising an old one. Notwithstanding the fact that it may be a repetitive order, this precautionary measure has a number of advantages. It insures against the possibility of a repetition of errors in designing, affords an opportunity for the improvement of previous models and sets up a bulwark against any unsalable material finding its way into the storeroom.

Through a system of standardization of parts and engineering records, this department makes the best possible use of every design on record. Previously a statement was made that the products as a whole were subject to frequent changes in design. This condition has been overcome to a very

great extent by the standardization of parts. It may be noted here that this particular industry lends itself very readily to the use of standardized, interchangeable parts.

Immediately following the activities of the engineering department, the manufacturing order, drawings and bill of materials are returned to the planning department from which point the routing division begins to function.

In this branch of the work of planning, the job is analyzed, the finished product being broken into its component parts and classified, from which point comes the issue of materials for the manufacture of those parts and the assignment of the different operations to the machines and men according to their various requirements and capacities.

Routing Department. This analysis assumes the form of route charts and route sheets. These convey the necessary information to the time study, scheduling and despatching departments. These are also the basis for making permanent records of all procedure, so that a repetition of an order will simply involve routine work. The routing department has available important data such as the locations and capacities of machine tools and work places, as well as a detailed knowledge of plant conditions which enables it to make the best possible use of equipment. Jobs are subdivided according to the grade of skill required and subsequently men are assigned to the class of work for which they are best fitted.

As a result of this analysis it is possible to obtain accurate costs of each operation on each component of a product as well as on the completed product itself. From the standpoint of good cost keeping, this is not only desirable but necessary, particularly where economies are to be effected in individual

machine or hand operations, through the introduction and use of labor-saving devices or the simplification of designs.

The function following routing is the assignment of raw materials to the various processes which have previously been authorized by the routing division. A balance of "stores" and "worked materials" are maintained, in which maximum and minimum quantities are set. These are kept as low as is consistent with economical practice, but may be changed from time to time to meet any fluctuation in business.

Ordering and Storing Materials. Where quantities available for future use have reached the minimum set, a requisition for the purchase of new or additional material is issued, and after being duly authorized is forwarded to the purchasing department where a formal purchase order originates. The usual practice is to secure from the vendor a quotation and delivery date, as it is upon this date that the scheduling of work through the shop is based. Duplicate copies of this order are forwarded to the departments which are directly affected by it, i.e., production clerk, balance of stores and receiving department. This duplicate becomes the formal authority for the receiving department to accept materials from an outside source and also notifies the planning department that they have been ordered or have arrived so that plans may be made accordingly.

Upon arrival of materials they are inspected to ascertain whether they are in accordance with the standards of raw materials which have been established by the engineering department before being placed in stores. This is an exceedingly important factor in this industry because designs are in many instances based on the particular style or type of raw materials available and which conform to trade standards. Furthermore, wage rates are based on

the assumption that standards have been maintained. The storeroom is accessible to employees of the stores department only and no materials of any kind, or for whatever pretense, may be removed from the bin without a duly authorized "stores issue" charging them to some production or expense account.

This company does not operate its own foundry, although a somewhat elaborate but very efficient order system is maintained. In view of the fact that thousands of models and patterns must be classified, kept in first-class condition, stored and duly recorded when they are distributed among several foundries, strictly accurate records are indispensable.

Patterns are stored in a loft according to their design number, and by a system of cross indexing, it is possible to locate a pattern immediately whether it be in the loft, at any particular foundry or undergoing repairs. A careful record is kept of the number of parts constituting a pattern and the various alterations that are made from time to time. In this way a pattern is always maintained in first-class condition ready for immediate use.

Estimates from various foundries are solicited and the awarding of contracts is contingent on both prices and delivery dates. The latter forms a basis for the scheduling of work by the planning department. All castings must be of the grade of metal specified in the contract and are carefully inspected upon their receipt. To this company, the expense of machining a casting before defects are discovered is greater than that of discarding it in the beginning. As has been stated before, maintenance of standards in materials affects the setting of wage rates. After the awarding of the contract, a follow-up system is used which reduces to a minimum or entirely eliminates tardiness in delivery.

All castings are classed as "special stores" and as such are theoretically received by the storeroom and issued to the manufacturing order to which they belong in the same manner as any other article of stores. This insures the possibility of every manufacturing order bearing its legitimate expenses. The department supervising the ordering of castings is analogous to the balance of stores department, and for this reason it is sometimes designated the balance of "special stores" department.

Production Control. Production control is effected through the medium of the standard three hook bulletin or control board and the use of various operation orders, move orders, time cards, etc. The function of printing or typing these orders and the arrangement of the several route sheets into a compact book or file, which is indexed alphabetically, occurs immediately following the ordering of castings and is purely routine work.

Practically every job that is performed in the shops is on a task and bonus rate, which is based on time studies. In the early days of the period of organization development in the Tabor Company, it was necessary to make an exhaustive study of every task. Very frequently this developed into a long series of experiments in order to determine the one best method of performance and to provide the proper equipment.

The elimination of a constant repetition of this procedure for every job was effected by the introduction of what was termed "elementary time study data" and of specially constructed slide rules which determine the speeds and feeds for each class and size of machine. By this means it is now possible to compile instruction cards for new jobs without resorting to the long and arduous method of time studies,

excepting in extremely infrequent and unusual instances.

Standards of operations are maintained by the use of instruction cards and "tool lists" prescribing the exact method to be followed and the proper equipment to be used. These are classified and filed in the time study department whose function is performed immediately after that of writing the forms previously mentioned. This consists mainly of placing the proper instruction cards and tool lists in their respective route files and computing the time for any required number of units on the order, after which it is ready for scheduling.

A master schedule, which has been previously compiled and used to regulate work in the planning department, now becomes the basis for all minor scheduling. An order of work is arranged which is to control every activity in the shops and which must be adhered to by everyone notwithstanding any personal opinions or objections, even though they are ever so plausible. Foremen may suggest, but cannot authorize a change. The reasons for this are quite obvious, and in passing it might be said that in any well regulated organization, which is so sensitive to the ebb and flow of conditions, a continual interruption of well laid plans would soon lead to ultimate disintegration.

The availability of raw materials for jobs is indicated on the route sheets by a system of checking which has been done either by the balance of stores, balance of special materials departments or other authorized persons, and the function of "despatching" now begins. The three hook bulletin board, mentioned above, becomes the receptacle for the operation orders which have been removed from the route files. They are placed on these hooks according to the order of work.

Orders for the transportation of materials are issued to move men, the tools and equipment, instruction cards and drawings having been delivered to the machines prior to starting the job, so that the minimum of delay occurs and the entire mechanism of shop supervision begins.

Immediately upon the issue of a time card to a worker authorizing him to commence work on a job, gang bosses, speed bosses and inspectors are at his service and contribute in every manner possible to facilitating the execution of his task. These functionaries act in the capacity of instructors rather than bosses, as all matters of a disciplinary character are referred to a higher authority for final adjudication. This one fact is commendable, in that it precludes the possibility of a worker being subjected to the prejudices of an indiscreet foreman which might ultimately result in an unwarranted dismissal. All work is regularly inspected both in starting and in finishing each operation, as well as in the final process of assembling. Any defects in materials that were impossible of detection prior to that time, imperfection of workmanship that might occur during the process, or errors in planning or designing are checked immediately. In this manner, responsibility can be placed and corrections made so that a repetition of such conditions can, to a great extent, be prevented.

Upon the completion of an operation, all tools are immediately returned to a centralized tool room for inspection, repairs, grinding, etc., so that they may be maintained, in their highest state of efficiency, available for future use. This fact would be utterly impossible of accomplishment, were they to remain

in the shops and in the possession of the individual worker.

Time Card. Of the various forms that are in use, the time card is the controlling factor in the operation of the production control system. The issue and receipt of this card determine the time at which the operation orders are to be placed on the bulletin board. It is the medium by which elapsed time is recorded. It constitutes the authority for the payment of wages and subsequently becomes, in conjunction with material issues and inspection reports, the basis for cost collection and allocation.

Procedure After Completion. The product, upon its completion, is immediately placed in stock and the final inspection order becomes the authority for both entering it on the balance sheets or stock records and closing the manufacturing order. The shipping order, which had previously been filed pending the manufacture of the product, now becomes active and follows the same procedure as when materials are shipped immediately from stock and the cancelled manufacturing order is forwarded to the cost department as a formal notice to close the account for that particular order.

Cost System. It would be remiss if reference to the complete cost system maintained by this company were omitted. By a system of machine and other indirect expense rates such as administrative, selling, engineering, etc., and an accurate knowledge of costs of materials and direct wages, it is possible to make comparative analyses of costs of different products and their various components and to effect the allocation of other expenses with a degree of accuracy that is otherwise seldom possible of attainment.

Plant Engineering as a Service to Production Management

By CONRAD NEWTON LAUER

General Manager, Day & Zimmermann, Inc., Engineers, Philadelphia, New York, Chicago¹

MUCH water has run under the bridge of American manufacture since the completion in December, 1790, of the first cotton mill in America—the Slater Mill at Pawtucket, built by him who has been called “The Father of American Manufacture,” Samuel Slater of Rhode Island. Crude as it was, this earliest cotton mill in New England can be taken as the first American manufacturing plant, the progenitor of modern industrial establishments in the United States.

The part needs little reiteration which engineering has played in the progressive development and refinement of plant construction and of production methods. Perhaps the beginnings of engineering's contribution are found in the application of mechanical drive in industry, whether directly from water power or from the steam engine. Later was to come the application of electricity, resolving itself finally into modern electric-drive, with all of its reliability, economy and flexibility. The engineer's is a most important function in America's industrial development. It will be my purpose in the following pages to indicate something of what form these contributions have taken. You will see that not only do the strictly technical considerations come into the picture, but the economic as well.

¹ Mem. American Society of Mechanical Engineers, Mem. Franklin Institute of Pennsylvania, Mem. National Electric Light Association, Mem. Pennsylvania Electric Association, Mem. Newcomen Society (London).

Seventy years is short indeed as a measure in the time element of human progress. Yet during the past seventy years in these United States the development of production has been such that the yearly value of manufacture has increased sixty-two fold, while population has increased only five fold, per capita wealth, nine fold and total wealth, forty fold. Engineering's part in all of this is self-evident when we consider what the application of the mechanic arts has meant, wherein an increase of only five fold in population during the past seventy years has brought about the immense increase in manufactured production and its closely related indices of wealth. Viewed popularly and in terms of the figures I have just given you, we might almost take it that in the consideration of men and mechanism our present 110,000,000 population, *so far as its productive effectiveness is concerned*, has been multiplied twelve fold by the employment of mechanism.

APPLYING ENGINEERING TO INDUSTRY

And now as to the function of engineering in modern production. Engineering has been defined by the American Society of Civil Engineers as

the creative science and art of applying economically the materials and forces of nature to the use and convenience of man.

In the broadest aspects, engineering is a science in that it is based on physical laws and an art in that its application of these laws to productive enterprise assists in the development of progress,

the creation of wealth and the well-being of mankind. The practice of engineering requires not only a technical knowledge of physical laws, material properties and the forces of nature, but the economic and progressive application of these resources in a practical and workaday world.

The broad field open to the application of scientific principles calls for many varieties of engineering and has resulted in numerous specialized branches of the profession. We have been accustomed to classify the five major divisions of engineering into civil, mechanical, electrical, mining and chemical. However, with the numerous sub-divisions and frequent overlapping of the varied branches, it has become a custom to identify the specific field by the more general use of sub-titles, such as automotive, marine, military or hydraulic engineering, and the like.

Plant Engineering, with which this paper deals, may be defined as that branch of industrial engineering which has to do with the design, the equipping and the operation of manufacturing plants, mercantile establishments, terminal warehouses and the wide variety of other buildings used in the industries. That particular phase which it is my intention to discuss, is the preliminary engineering work done in advance of construction, the purpose of which work is to design the plant to suit the process and the results of which establish the physical conditions and building limitations with which production management must contend.

The factory manager, whose problem it is to produce articles of commerce at a profit, has to deal both with physical and human elements, which together determine whether the materials used, the facilities available and the energy expended will yield a fair return on the investment. The human

factor is the most difficult and usually the most expensive element in production costs and therefore merits special consideration both in the selection of the factory site and in the design of the plant.

The abundance of natural resources and the high wage rates established in the United States have given the American engineer alike opportunity and incentive to develop new inventions and labor-saving machinery. These not only are marvels of ingenuity but they have enabled workers to increase their productive capacity, and have enabled them to adopt higher standards of living than otherwise would have been possible. The old fallacy still accepted in England that greater unemployment results from the adoption of improved methods and machinery long ago proved a myth in this country; in fact, two or more industries have sprung up where only one existed before. The increased capacity resulting from improved facilities often necessitates a readjustment of duties in some industries or the transfer of some of the workers—mostly in unskilled labor—to some other line of endeavor. Temporary unemployment directly attributable to new developments in manufacturing methods has been negligible when compared with the annual labor turnover still occurring in industries affected by seasonal fluctuations and business restrictions.

PLANT MANAGEMENT—ITS FUNCTIONS

The chief function of plant management is to produce articles of commerce of the type and quality for which there is a demand at sufficiently low costs to insure fair earnings on the investment. Management, therefore, must deal with the purchase of raw materials, their economic conversion into finished or semi-finished products, and must deal with the sale of the products made to

users or distributors. Management's supervision has to do with the direction of human labor and with the use of physical facilities with which the work can best be accomplished.

The selection and development of the facilities of production are a part of management's duties inasmuch as management must of necessity know the process of manufacture to be adopted and the types of tools and amount of equipment to be installed to meet the production needs. Management, therefore, should have within its own organization specialized knowledge as to the details and methods of production in order that the manufacturing may be economical and that losses may be reduced to a minimum.

OBTAINING MAXIMUM OUTPUT

The task of the production engineer is to improve the process, the methods and the facilities of manufacturing, in order that the productive capacity of each worker may be increased and the maximum output may be realized per unit of floor space or per dollar of investment. The service is valuable which the industrial engineer, who designs and equips a new plant, can render to the production management that will operate it, since it has considerable bearing on the future operating efficiency of the plant and indeed is a determining factor in its future development.

Let us examine into some of the fundamental considerations involved. The relative location of departments and of equipment in departments affects the amount of trucking or methods of handling necessary to move materials from one operation to the next. Some operations in the process may be of such character that from the standpoint of comfort, safety or convenience, it is necessary to isolate them with their equipment in separate rooms

or buildings necessitating a detour from the desired *straight line* or *progressive flow* of materials. With a diversified line of products, ideal routing for one line or group of parts may not be satisfactory for another line requiring a different sequence of operations. A compromise in department or machine locations is sometimes necessary in order that the routing preference may be given to materials or articles produced in greatest quantity or having the heaviest weight or largest bulk.

The size, location or topography of the factory site also may determine whether multiple-story buildings should be given the preference over the single-story factory, or whether a combination of single- and multiple-story buildings will best serve the real estate limitations and process requirements.

It is evident, therefore, if physical handicaps are to be avoided, departments must be arranged in logical sequence, balanced production facilities must be maintained, and handling costs must be kept at the lowest possible figures. In advance of construction or of moving into an existing building, ample study should be given by the industrial engineer to such important factors as the site limitations, the preferable layout to suit the manufacturing requirements and insure an efficient arrangement of departments, and to the type of building best adapted to the process, as well as to the important question of provision for future expansion.

WHY MANAGEMENT NEEDS THE ENGINEER

The great majority of enterprises start in a small way, either in a building where floor space can be leased or in a small plant built or rented for the purpose. The larger industries are gradual developments from small or are consolidations of several industries con-

centrated at one or more plants. At some stage in its development, the business may have expanded to such an extent that the plant has outgrown its original site, or changes in the art or the market may justify its relocating to obtain more economic advantages or to avoid physical handicaps which restrict development. More frequently additions are made to existing plants to provide space for needed expansion or permit new departments to be added. Whatever the reason is for enlargement, the time is usually opportune for the management to have a development plan established, if it was not provided originally, so that immediate additions will be made in conformity with a predetermined plan and space reserved where needed for future extensions.

Although management is or should be organized to improve its production methods and facilities, still the building operations for the average plant occur at such infrequent intervals that management is not always justified in retaining in its organization specialists familiar with building design, with industrial layouts, the economics of materials handling, with power plant or substation design, electric transmission or distribution, and the like.

The organization in charge of production usually is too busily engaged with its own problems of maintaining production or improving methods to be able to take on the additional duties of developing detail layouts, plans and specifications covering building extensions or new plants. Production management likewise is so close to the details of manufacture and the inherited traditions of the trade that it often is difficult for those primarily occupied with production problems to visualize the business or its future in its broader aspects, free from all preferences, prejudices or precedents.

When it becomes necessary to carry through new industrial enterprises, plant expansion or rearrangement, production management usually realizes its own shortcomings and does not hesitate to augment its own organization during the development period by retaining outside industrial specialists who are equipped to handle the various problems of layout, design and construction that will arise and must be solved economically and satisfactorily. Production management must of necessity have detail knowledge as to the plant capacity desired, the immediate and future needs of the business, and the process of manufacture. The industrial engineer who is to undertake the work of designing the plant, should be familiar with the principles and details of plant engineering and industrial architecture, with the manufacturing methods and facilities in use in other or similar lines of industry, with modern systems of administration, sanitation and safety requirements, and familiar with other factors which may have a determining influence on the plant design. When the specialized knowledge of production management is combined with the general knowledge of the industrial engineer, the resultant plant may be expected to be an efficient one, designed to suit the process with the needs of the future largely anticipated in the plan adopted for future plant expansion.

By the nature of things, the industrial engineer must analyze every detail entering as a component factor in his problem related to industrial plant design and construction. Always must he visualize the needs of the completed plant when in actual operation. Imagination comes into the picture but interpreted through experience. It takes years of background, in the widest variety of industries, to give that training which the industrial en-

gineer must have if all of the components are to be recognized and foreseen. Obviously a vast amount of detail is necessary in these exhaustive studies. The scope of this article prevents my giving more than a résumé of what these factors are.

TYPE OF SERVICE RENDERED

By way of introduction, I will say that the service which plant engineering can render to production management in an industrial plant development will vary with the type and size of the project. In general, however, the problems to be solved or the various factors to be considered may be summarized:

- (1) *Economic selection of plant site*, if a new plant is being considered.
- (2) *Preliminary industrial engineering* as a basis for establishing the plant layout, which includes a *detail study of the following*:
 - a. Investigation of proposed site with respect to topography, highways, railroads, sewers, residential districts, etc.
 - b. Determination of specific manufacturing requirements and compilation of data relating to present and future needs.
 - c. Determination of fundamental principles that will be followed in new plant as concerned with the administration of all manufacturing details.
 - d. Consideration of features exemplified by plants recently built for the same general class of work.
 - e. Determination of mechanical and electrical equipment that should be provided.
 - f. Information on power requirements and distribution, types of drive, and sources of power.
 - g. Determination of approximate arrangement of equipment and processes based upon elemental routing and administration requirements.
 - h. Determination of floor areas required for manufacturing, storage, assembling, and for auxiliary departments, for offices, and for future expansion.
 - i. Determination of total property area needed at once (if not yet purchased), and amount that should be reserved for the future.
 - j. Investigation of departmental needs and restrictions affecting locations.
 - k. Determination of number and distribution of employes in order that lavatories, and locker rooms may be of suitable size and location to meet the sanitary or legal requirements.
 - l. Determination of railroad and trucking facilities that should be available for receipt and shipment of materials.
 - m. Topographic survey of property, giving locations of highways, railroads, sewers, water mains, etc.
 - n. Preparation of alternate layouts of departments, segregating them into one or more buildings of assumed size and shape, taking into account all the foregoing factors, including the property restrictions.
 - o. Reconsideration of all work done so far and preparation of a revised layout incorporating as far as possible the best features of the various preliminary studies, including outline drawings of buildings.
 - p. Preparation of cost estimates based upon unit prices.
 - q. Determination whether estimated expenditure would result in a "fixed charge" consistent with the probable profits of the business, i.e. can the business carry the necessary investment.
 - r. Determination whether owner is prepared to make the total justifiable expenditure.

- s. Revision of layouts if required by financial limitations and placing data and plans in suitable form to be used as a basis for the preparation of architectural and engineering drawings and specifications.
- (3) *Preparation of detail plans and specifications.*
- (4) *Supervision of construction.* This work includes:
 - a. Selection of responsible concerns to bid upon plans and specifications and securing competitive bids.
 - b. Tabulation of bids, conference with owner, followed by placing of contracts.
 - c. Supervision of construction work, including inspection, scheduling of work, field accounting, etc.
 - d. Installation of "service equipment" and all standard and special machinery or appliances needed for industrial purposes.
 - e. Authorizing monthly payment of monies based on the progress of the work.
 - f. Certifying as to completion of contracts.
- (5) *Installation of equipment* which includes:
 - a. Locating new equipment and transferring used equipment and accessories from old to new plant.
 - b. Training the force of administrators and operators along the lines necessary to bring about the most efficient utilization of the buildings and facilities provided.
- (6) *Co-operation with production management* during the entire period of plant development. Consulting service in connection with the various production or development problems that occur from time to time.

IN CONCLUSION

And now to summarize: The services of the engineer are of far-reaching importance in industry. Men and mechanism, since the early days of Samuel Slater's pioneer manufacturing activities in Rhode Island in 1790, have accomplished in America an achievement in present-day quantity production at which the world marvels. Whether always recognized as such or not, engineering has contributed and contributes in ways that I have attempted to outline. You have seen that seventy years of progress in the United States have meant a sixtyfold development. Population could not have sustained this production had not the creative science and art of engineering contributed what they have.

Plant engineering is a very definite service to production management and will so continue as our already immense manufacturing industries continue to expand.

Engineering has that happy faculty of bringing applied science to the aid of American business initiative. By the same token, the engineer must combine with his strictly technical knowledge a sound understanding of the economic principles involved in his industrial problem. No matter how carefully is an industrial plant designed, the engineer will have failed does he not take into consideration the economic factors which, together with the engineering features, will determine the business success or failure of the particular industrial plant as an enterprise.

Some Aspects of Personnel Research in a Manufacturing Organization

By J. W. DIETZ

Secretary, Personnel Committee, Western Electric Company

THE Western Electric Company's personnel problems are like the shoe problems of a growing family. The boys are different, the feet are different, the shoes vary, the prices vary, the maintenance is not standard. Considerable experimentation and investigation are necessary to get the best possible shoes for each boy. Out of this experience comes more knowledge about the feet and the shoes. Good shoes cost more than poor shoes but they are more economical in the long run.

If there is any manufacturing problem full of variables it is the personnel problem. The Western Electric Company manufactures communication apparatus, installs telephone central offices, and purchases and sells electrical supplies. It acts as the supply agency for the Associated Telephone Companies of the Bell system. Its family is large, some 45,000 in all, and is located all over the country, but concentrated for the most part in more than fifty of its principal cities. Groups of employees vary in size from a half dozen in a branch warehouse to 25,000 in its largest manufacturing plant, Hawthorne Works, Chicago. There are 34,000 men and 11,000 women. Some have been with the Company many years and others are newcomers. There are skilled, semi-skilled and unskilled workers, salesmen and clerical workers, highly trained technical experts, a large supervisory force and an executive staff. The pay-roll forms a high percentage of the total cost of the Company's products.

Any progressive manufacturer is

anxious to improve the quality of his product, reduce operating costs, eliminate waste, improve service, increase capital turnover and net profits. These days he is coming to believe that doing a better job in relation to the employees and the public is bound to have a helpful effect on all the material factors of his business. Progress in human relations must at least keep pace with technical developments and other improvements in management.

In the Western Electric Company right relations with employees are looked upon as fundamental to the success of the Company. We believe, too, that these relations to be right must be founded upon the conviction of every employee that the policies of the Company are based upon a spirit of justice in its dealings with every person with whom it comes in contact.

FOUNDATION FOR PERSONNEL RESEARCH

Our policies in employee relations are of long standing and are familiar to older employees through experience. They have been formulated and distributed in pamphlet form to all those occupying supervisory positions to insure that, in such a large and widespread organization, there may be a common understanding of the ideals, motives and practices of the Company in this field. The responsibility for making personnel policies effective is placed upon the supervisory force. Therefore, no question arises of divided responsibility in carrying on the entire supervisory job.

These policies are the foundation upon which our research program is built. Quotations from the statement as issued to all those responsible for directing the work of others will best illustrate the scope and conception of the personnel program:

It is the policy—

- (1) To pay all employees adequately for services rendered.

When the individual records of all employees are reviewed periodically, it is your duty to see that their rates of pay are adjusted fairly. Compensation should be based upon ability, responsibility, length of service and capacity for growth, giving due consideration to cost of living, general business conditions and wages paid by other concerns in the same territory for comparable work.

- (2) To maintain reasonable hours of work and safe working conditions.

Special attention must be paid to conserving the well-being of employees in equipping and maintaining shops, warehouses, offices, restaurants and rest rooms and other facilities for comfort and convenience. Careful consideration must be given to hours of work, vacations, medical service and payment in case of absence.

- (3) To provide continuous employment consistent with business conditions.

In the management of the business a continuous effort must be made to provide steady work and permanent employment. When reduction in force is unavoidable, consideration should be given to retaining long-service employees. When additions are made to the force, preference should be given to former employees. Continuity of employees' service records should be guarded.

- (4) To place employees in the kind of work best suited to their abilities.

Consideration must be given to

placing each employee in the kind of work which offers opportunity for his maximum growth and usefulness. Great care should be used in assigning employees to work when they are first employed, and trial should be given on different types of work when necessary.

- (5) To help each individual to progress in the Company's service.

When vacancies occur, those already in the Company are entitled to first consideration. Every employee should understand the relation of his work to that of the Company as a whole, and there should be provision for training on the job, variety and progression of experience. Information and advice should be made available for those wishing to take advantage of outside educational opportunities.

- (6) To aid employees in time of need.

It is necessary for you to understand fully the purpose and scope of the Employees' Benefit Fund for giving aid in time of disability due to sickness or accident, and for granting retiring allowances. You should keep informed regarding loan funds available for meeting other emergencies.

- (7) To encourage thrift.

You are responsible for keeping your people informed and interested in the stock purchase plan and other means available for encouraging thrift. Employees desiring information and counsel should be put in touch with those best qualified to advise on matters of home buying or building, use of banking facilities, insurance programs and other personal financial problems.

- (8) To co-operate in social, athletic and other recreational activities.

Encouragement may be given by supplying facilities, by sharing in the operating expenses of organized activities of this character, and by making better use of opportunities existing in the community.

- (9) To accord to each employee the right

to discuss freely with executives any matters concerning his or her welfare or the Company's interest.

It is your duty to establish the conviction among those whom you direct or with whom you come in contact that sympathetic and unprejudiced consideration will be given to any employee who wishes to discuss with executives and supervisors matters of his or her welfare or the Company's interest.

- (10) To carry on the daily work in a spirit of friendliness.

As the Company grows it must be more human—not less so. Discipline, standards and precedents become more necessary with size, but the spirit in which they are administered must be friendly as well as just. Courtesy is as important within the organization as in dealing with outsiders. Inefficiency and indifference cannot be tolerated, but the effort of supervisors must be increasingly directed at building up in every department a loyal and enthusiastic interest in the Company's work.

PURPOSE OF PERSONNEL RESEARCH

With these employee relations policies as a foundation, the purpose of personnel research becomes the evaluation of experience and the preparation of information to serve as a basis for establishing or modifying policies and making them uniformly effective throughout the Company. It is also the purpose to keep them abreast of sound developments in this constantly progressing field.

The problems with which personnel research is concerned are of two kinds:

1. Problems of Administration or those problems which deal with the formulation of policies.
2. Problems of Management or those problems which deal with the execution of policies.

Problems of Administration. There are many decisions to be made regarding employee relations which involve the formulation of policies and must be made by experienced executives. Analysis of past experience and the careful study of facts bearing on the case are necessary for the formulation of sound, progressive policies.

Examples of research projects undertaken to form a basis for such executive action are:

A. Personnel Conditions

1. Analysis of wages and force losses of hourly-rated employees.
2. Study of working conditions affecting all employees, including hours of work, methods of payment, payment for holidays, vacations, overtime, etc.

B. Analysis of Contacts Between Employees and the Supervisory Force

To determine upon ways of stimulating the co-operative spirit among employees.

C. Thrift Data

What sort of information will be useful to employees in working out their personal financial programs such as savings plans, home-ownership plans, insurance plans?

D. Employee Census

To supply a general background of facts about employees, including nationality, age, length of service, salary, education, etc.

Problems of Management. Having formulated policies in employee relations the next step becomes their uniform interpretation and execution throughout the Company. Personnel departments have been established in each main department of the Company to advise and assist executives and supervisors in their dealings with

employees and to render service to employees in general. The type of research carried on by these Departments is best illustrated by listing some of the studies which they have made to improve their service.

A. Employment

Production load—co-ordination of manufacturing schedules with help required to do the job.

Analysis of local population for information as to labor supply.

Study of sources of employment and conditions affecting employment.

Study of applicants not accepted for employment.

Study of reasons for employees leaving the Company.

Analysis of expense and results of advertising for help.

Development of trade tests for selected occupations.

B. Helping Employees to Progress

Studies of employees' progress.

Study of plans for up-grading, transferring and promoting employees.

Study of results of training.

C. Health and Safety

Elimination of industrial hazards.

Occupational placement with relation to physical fitness.

Analysis of sickness and absence reports.

Analysis of accident reports with reference to prevention.

D. Employees' Service

Analysis of employees' participation in stock ownership.

Analysis of payments from benefit funds.

Sales of Company products to employees.

E. Compensation

Studies of market rates of pay.

Salary progress of employees.

Revisions of rates of pay.

Payment for overtime work.

ORGANIZATION FOR RESEARCH

A General Personnel Committee has been appointed. Executives represent-

ing the main departments of the Company are members.

The duties of the Committee are briefly as follows:

(1) The Committee shall formulate policies and methods concerning the different phases of employe relations.

(2) The Committee shall promote the uniform interpretation of the Company's employe relations policies in all departments and among all groups of employees.

(3) The Committee shall review existing personnel practices, programs and methods throughout all departments and make recommendations regarding improvements.

(4) The Committee shall keep informed as to the effect upon employees of policies, programs and methods in operation within the Company.

(5) The Committee shall keep informed concerning activities in the field of human relations in outside organizations and business in general.

In order to carry on the work of the Committee a *full time staff* is maintained under the direction of the Secretary. The Secretary makes the necessary contacts within the Company, with outside organizations and other industrial concerns, and carries on the Research which is fundamental both to the formulation of policies and their successful execution.

Other fact-finding agencies of the Company make important contributions to the Personnel Research program. Studies made by the *General Statistical Department* of business and employment conditions, and the cost of living; statistics prepared by the *General and Branch Accounting Department* as to the numbers, distribution, etc., of employees; research carried on by the *Development Branch of the Manufacturing Department* concerning the best methods of doing work; the analysis of causes and costs of sickness and accidents by the *Benefit Fund Department* all supply vital information in the personnel field.

CONCLUSIONS

The place of research in business organizations is daily becoming more firmly established. Research in the physical sciences—chemistry, physics, metallurgy and mathematics,—was the first research program to be recognized by the Bell system and the Western Electric Company as fundamental to the development of the communication art. In the last twenty years research in this field has developed from casual local experimentation and apparatus design to a centralized technical organization for carrying on extensive engineering, research and development work.

Recently economic research has come to be recognized as one of the activities fundamental to successful business planning. Ten years ago our Sales Department began to investigate to see what could be learned about the sources of net profits. Interesting facts were discovered concerning the profitability of certain kinds of orders and of certain lines of merchandise. Research is a well established function of the Purchasing Department also. Studies are conducted to facilitate intelligent decisions and economize the time of buyers; investigations are made of substitution of materials to obtain greater economy or better market conditions; reports are prepared of market conditions to aid buyers in negotiating contracts intelligently.

At the present time, a consideration

of the contribution which the social sciences may make to industry has begun to receive increasing attention and it is in this field that personnel research has its place. Problems of vital importance to manufacturers in which scientists are now interested indicate the trend.

(1) Fundamental aptitudes and capacities of individuals.

(2) Possibilities and limitations of individual development along certain lines.

(3) Fitting the handicapped into suitable work.

(4) Supplying incentives for workers to make maximum use of their capacities.

(5) Organization of work to make possible the fullest use of individual ability in co-operative effort.

Quite theoretical? Yes, but so was the electronic conception in relation to the vacuum tube. Today radio broadcasting is used and enjoyed as an everyday, commonplace affair, as a result of fundamental research in the field of physical science.

There are many problems in the personnel field about which little is known as yet but which may prove revolutionary to present business organization when science has helped to find the answer. There are increasing evidences of a tendency to attack industrial problems from the standpoint of the individual worker rather than the mass. What is really best for you and me is best for our industries.

Maintenance of Contact with Employees of the Philadelphia Rapid Transit Company

By DR. A. A. MITTEN

Vice-President, Mitten Management, Inc.

THE greatest asset possible to management is the good will of the workers, for largely upon their effectiveness depends the success of the enterprise, particularly if it be a public utility whose rates quickly reach the point of diminishing returns when they are forced up to pay for strike losses or to meet the expenditures due to heavy turnover or careless work.

It is surprising that more thought and effort is not given by management generally to this vital phase of industry. Perhaps it is because of a settled opinion that the relations between employer and employee must always be strained, and that any effort to maintain a more frequent or direct contact than through the paymaster's office is likely to stir up a hornet's nest of mixed emotions. The employer holding this viewpoint has not touched the possibilities which lie in his business, for he has failed to harness the greatest revenue-producer in his plant—the good will of his workers.

Some years ago, a student of industrial problems visited the Philadelphia Rapid Transit Company, and after a careful inspection of the plant expressed his surprise at the amount of thought and time given to the working conditions of the employee. He had just come from the western part of the state where he had been studying conditions in the soft coal industry. Said he:

In the offices of these companies each door bears a sign "Superintendent of Mines," "Superintendent of Mules," "Superintendent of Power," etc., etc., but I do

not recall that any official of the company had directly under his charge the welfare of the men who dig the coal. In your organization, however, I find that this phase of your work is uppermost in the mind of the principal leader in the management, and all through the ranks of the subordinate officers there is a remarkable degree of consideration for the workers. Perhaps, after all, some of your success is due to this attitude.

How nearly his supposition was correct may be deduced from the fact that more than nineteen million dollars a year are saved to P. R. T. property through economies and efficiencies which would not be possible but for the earnest co-operation and willing effort of P. R. T. employees. Sixteen million dollars a year of such savings were proved before President Wilson's Federal Electric Railways Commission in 1919, and later before the Pennsylvania Public Service Commission, and this amount grows with each succeeding year. This means an annual saving to the company of almost \$2,000 per man employed, for which a wage participation is paid, as will be explained later in this article, amounting to about 10 per cent of the total economies and efficiencies. These are itemized for 1924 as follows, and are exclusive of the enormous saving to the community at large because of the strike-proof service which our plan makes possible.

When such a startling tabulation is possible in an industry which is notorious for its labor disturbances and disagreements, it is perhaps not surprising that a great deal of interest is evinced in the means by which we maintain a

Passenger receipts induced by superior salesmanship—producing increased net revenue of	\$3,380,000
Advertising receipts attributable to better marketing of available space	250,000
Saving in operating costs due to scientific car scheduling and routing, etc.	8,830,000
Increased energy production per unit fuel consumed and saving by more economical consumption	2,470,000
Accident prevention work and enlightened policy of claim settlements	980,000
Developed production in car repair shops, refinements in methods of painting and maintenance	1,440,000
Accelerated track relaying and repair	180,000
Benefits derived from low ratio of labor turnover	390,000
Improved fare collection and station methods on subway-elevated	470,000
Savings accomplished by means of bulk purchases, standardization reduced handling of supplies	380,000
Reduction in fire insurance premium in recognition of improved fire prevention methods	160,000
Miscellaneous improvements in operating, maintaining and accounting	125,000
	<hr/>
	\$19,055,000

contact resulting in such financial benefit to our property, with the resultant advantage to our customers, who are the street car riders of Philadelphia and vicinity.

Mitten Management bases the proper maintenance of contact with employes upon the following premises, each one of which will be discussed in detail:

1. An attitude of complete frankness and fearlessness in all dealings with the employes.
2. Collective consideration on every point which involves the wages or working conditions of the employes.
3. A reasonable consideration for the social welfare of the employe insofar as it is affected by his employment.
4. The payment of a wage adequate to the necessities of life and comfort, and sufficient to permit of reasonable savings.
5. To encourage the laying aside of a regular part of the wage for protection against the rainy day.
6. Provision for participation by the employes in such increased earnings as are made possible by the increased effort of the employes.
7. Encouragement of the investment of this added wage in such a way as to make the employes owners as well as workers.

1. An attitude of complete frankness and fearlessness in all dealings with the employes.

When T. E. Mitten came to Philadelphia in 1910, he found a hostile body of men divided into three rival labor unions, each fighting the other and all fighting the management. The men were unable to agree on any one of these organizations as its contact point with the management, and finally accepted a plan which Mr. Mitten had prepared and which has since become famous because of its outstanding success.

At the outset, the men were assured of the intention of the management to base all its labor policies on the square deal. The men, however, had heard that sort of thing from previous managements, and were very thoroughly imbued with the impression that nothing that any management did could be right.

Years of patient effort, however, during which the policy of frankness and fearlessness was relentlessly followed in spite of many discouragements, finally led the men to a belief in the good intent of the management. The old barriers of prejudice and suspicion were broken down and have been re-

placed by close and enduring bonds of faith and confidence.

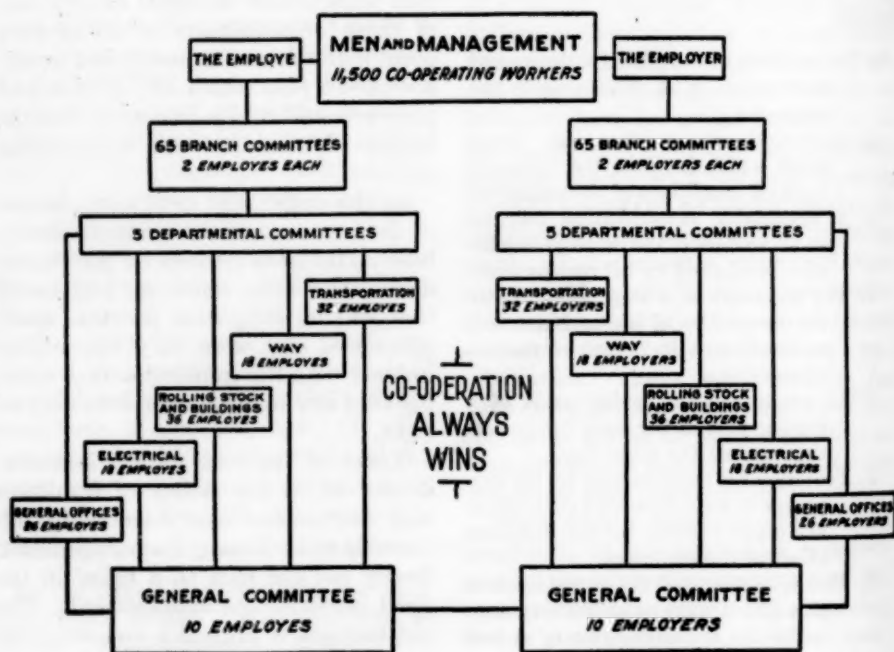
This development is best expressed perhaps in the life of one of the fomenters of the disastrous strikes of 1909 and 1910. For many years after the incoming of the management he was one of its most bitter enemies, his power being the greater since he was repeatedly elected by his fellows to represent them before the management. He was gradually won to a belief in the management, however, his capacity for leadership was harnessed for good instead of for evil, and last year he had the privilege of increasing the saving fund of his fellows, of which he was president, from \$2,000,000 to \$2,250,000. He is the leader of the company's Scotch kiltie band and is an individual tribute to the policy of frankness and fearlessness in dealing with the employees. His case is one of many, all of which are the best possible

evidence that men will appreciate and respond to fair dealing when they are brought to recognize it.

2. Collective consideration on every point which involves the wages or working conditions of the employees.

The Mitten co-operative plan for adjusting relations between employee and employer is based upon the fundamental principle that the successful running of a railway depends most upon the men who run it. Every employee six months or more in P. R. T. service has the privilege of voting for his direct representative in this plan of collective consideration.

The plan recognizes the right of employees to determine collectively upon all matters affecting wages, working conditions, and discipline. It provides uncontrolled election of employee representatives, elected by and from among



the employees by secret ballot. These with an equal number of representatives appointed by the president of the company constitute:

For Employee

Branch Committees
Departmental Committees
General Committee

For Employer

Branch Committees
Departmental Committees
General Committee

The branch committees serve as lower courts where local points of difference are for the most part settled on the spot.

All branch committeemen in each department come together to consider departmental matters. Questions not settled in branch committees are carried to the respective departmental committees, as a higher court, where by across-the-table discussion local branch differences are adjusted to the broader viewpoint of the department as a whole.

The general committees with equal representation from all departmental committees serve as a superior court for undecided questions and for the review of appeals. Here are considered the questions of administration affecting the interests of all.

Final arbitration—a supreme court—if needed, is assured through an arbitration board wherein men and management are each directly represented, while the public, which always finally pays, is given the deciding voice.

While a plant publication, *Service Talks*, is used to carry the messages from management to men, the best possible means of contact with the great host of employees is maintained through the employee committeemen,

about 130 in number. Before any plan in which the employees are vitally concerned is launched, or in which their unusual co-operation must be enlisted, the committeemen are brought together and the project thoroughly discussed. The committeemen then go before their constituents as the advocates of the plan, if the management has succeeded in putting its case before them in such a way that they believe in it.

Thus recently the committeemen won from their constituents a pledge to purge the force of every undesirable employee, which has been productive of great results. Again a ballot was successfully cast and counted in which ten thousand of the car riders expressed themselves within two hours in favor of a subway which the management is now advocating.

Three million dollars' worth of P. R. T. 7 per cent preferred stock was recently sold to our car riders through the medium of the men on the cars. Six days only were required before 13,000 of our customers had oversubscribed the issue. The feature which most appealed to these investors was an easy payment plan of one dollar per week per share, which can be made directly to the conductor on the car or to the cashier at the subway or elevated station.

Similar plans are constantly being successfully launched with the complete understanding of every man involved because of the method of direct contact secured through the co-operative committeemen.

Great rivalry exists among those desirous of representing their fellows. At some of the Transportation Committee locations, as many as fifteen men are sometimes in the running for the office, and all the methods of a political campaign are resorted to. As a result employees of a high type and

having the confidence of their fellow workers are brought into direct contact with the representatives of the management.

3. A reasonable consideration for the social welfare of the employe insofar as it is affected by his employment.

Mitten Management counts it a duty to see that no employe, except through his own extreme shiftlessness, can ever be placed in a position of want. As a result of this policy, every worker is economically independent, and not a single P. R. T. family is faced with the destitution which confronts 60 per cent of America's working class families at the time of the death of the breadwinner.

The Co-operative Welfare Association administers sick benefits, pensions and life insurance. Its officers are elected by the employes, and it is supported by weekly pay envelope deductions, the company paying dollar for dollar with the employes.

A helping hand fund is maintained for the benefit of employes who are overtaken by unusual hardship against which they are not fully protected by the Welfare Association. This fund is supported by the proceeds of employe entertainments, the sale of route guides on the cars, and similar moneys.

The Welfare Association conducts each year a two-day picnic at the Willow Grove Amusement Park, which is attended by 50,000 employes and their friends and families. Concerts by the company's 100-piece brass band and other musical organizations feature this event, while employer and employe mingle together in an annual festival of song and play. Great get-togethers are held in the open air pavilion, and it is usually at these meetings that new developments of the co-operative plan are launched.

4. The payment of a wage adequate to the necessities of life and comfort, and sufficient to permit of reasonable savings.

Wages are based on the average of those prevailing in other cities, and there is now under consideration a plan to base the wage on the purchasing power of the dollar in Philadelphia. This is believed to be the most economical and equitable method of wage adjustment, and if a practical plan can be evolved, it will no doubt be adopted.

The present plan has been rigidly adhered to, and the management has granted increases and the employes have accepted decreases with equal good grace over a period of many years. A change in the wage base, coming due because of wage changes in one or more of the three large cities used as the base, is thoroughly discussed in the general committees and approved by them before it is made effective. Thus every employe is given full opportunity to understand the reasons for the change. So successful has this method of contact been that on one occasion the employes eagerly deferred for many months a wage increase which was due them because they recognized the financial inability of the management to meet the wage increase at that time. During this same period of financial stress, they volunteered to lend the management their combined savings without interest. Thus Mitten Management has good reason to believe that the royal road to successful contact with the workers lies through frankness and a joint understanding.

5. To encourage the laying aside of a regular part of the wage for protection against the rainy day.

During the war period of high wages, when the general tendency of labor was to dissipate their unexpected gains, the

management warned the men that days of depression must inevitably follow. The result was the beginning of an employees' saving fund which now has deposits of two and a quarter million dollars so wisely administered as to have won high praise from the Pennsylvania State Commissioner of Banking. Regular deductions are made from pay envelopes, and thus the saving habit is instilled in hundreds who otherwise would save nothing. Through this contact the employee has learned the value of safe investment to such an extent that when we recently issued our \$3,000,000 issue of 7 per cent preferred stock for public subscription we had first to convince the employees of the wisdom of this plan because so many wished to transfer their savings from the 5 per cent saving fund to the 7 per cent stock, recognizing it to be only a shade less secure than the bonds in which their saving fund is invested.

6. Provision for the participation by the employees in such increased earnings as are made possible by the increased effort of the employees.

In 1922, in recognition of the millions of economies and efficiencies made possible by employee co-operation, a plan was started whereby employees received an added wage participation not to exceed 10 per cent of the payroll, provided that amount is earned over and above the sum required to pay the dividend on the \$30,000,000 capital stock of the company.

This plan has greatly strengthened the bond of unity between management and men, since it has given to the latter an added incentive to effort. Self-supervision is the natural result, and as such a plan of participation in profits is extended, a purification process takes

place in the force far exceeding anything possible by a system of inspection and rigid discipline, which becomes less and less necessary as the employees come more and more to appreciate that earnings are limited to their own capacity to produce.

7. Encouragement of the investment of this added wage in such a way as to make the employees owners as well as workers.

Added compensation, however, is but a sorry makeshift unless at the same time the employee is in a position to administer his added compensation wisely and well. With this in mind, the management advised the employees to invest their added wage in the common stock of their company. This has been done with the result that in three years the workers have secured 151,000 shares or more than one-fourth of the entire issue.

The stock is kept in a joint fund, administered by employee trustees, and the principal cannot be touched by the individual except by leaving the company's service, at which time he or his heirs receive either the market value of the stock or the amount actually paid into the fund, as the trustees may decide is best for the general advantage of the fund.

The par value of the common stock is \$50 per share. When the men began buying, its market value was \$30 per share and today it is selling at par for the first time since the incorporation of the company in 1902. If the stock were held individually, as is the case in most corporations which have made stock available to their workers, such an increase in value would no doubt mean a rush to the brokers' offices to realize and dissipate the profits. In the case of this plan, however, this is not possible, and the worker's earnings continue

HOW OLD ARE YOU? HOW MUCH LONGER CAN YOU WORK?

HOW MUCH MONEY WILL YOU HAVE WHEN 65?

PICK OUT WHAT THE RESULT WILL BE
FOR YOU, AND YOURS

Deposit in the saving fund only \$2 a week; and your wage dividend check every 3 months.

Present Age	Number of years of service before reaching 65	Monthly income after retirement including \$40 pension	Estate to leave to dependents including \$1,000 insurance
55	10	\$65	\$5,300
50	15	85	8,750
45	20	105	13,425
40	25	130	19,625
35	30	175	27,800
30	35	220	38,475
25	40	280	52,350

The Chief has said: "Our work now offers unequalled opportunity." — Service Talks No. 55.

THIS IS THE NYMAN FORMULA—IT MEANS A LOT TO YOU, AND TO YOUR FAMILY

to be used to his advantage and to gain for him a greater ownership in the industry in which he is engaged.

Dividends on the stock are paid quarterly to the participants in the fund, and as from year to year the holdings of each employe have increased, his return has likewise increased. With each succeeding year, therefore, he has a more concrete lesson in the value of investing, instead of squandering his means, and a steadier and happier employe is gained for the company and a better citizen for the community.

One of the recent presidents of the Co-operative Welfare Association sensed the possibilities in this plan for the humblest employe, and set it forth in a form which came to be known as the Nyman formula. It is here set forth as illustrating how the financial condition of the employe can be improved to an almost incredible degree when faithful and loyal service are coupled with frugality.

The marked success of employe ownership of P. R. T. has led Mitten Management to the belief that herein lies the best possible substitute for the old pride of craftsmanship or merchan-

dising which has passed with the success of the industrial revolution. The old direct contact between master and man, working over the same anvil and dining at the same table, was a steady influence to civilization. The understanding which was the direct result of this contact made for happiness and contentment. Industrial disputes are nothing more than a painful evidence of the removal of this understanding. The best answer yet presented would seem to be to encourage the worker in his task by giving him a greater participation in the proceeds of his toil, growing in proportion to his ability to appreciate and understand the responsibility which such ownership entails.

This is not a theory, but a fact immediately to be faced. Labor is fast becoming capital, and herein seems to lie the hope of our industrial civilization. The ideal contact between employer and employe will be found when labor so definitely controls capital that in actuality labor will select its own employer. Who will be so bold as to predict that the employer selected will not be the one who will most properly administer the financial affairs of the industry which the worker owns?

Introducing the Practical Man to Modern Management

By H. S. GILBERTSON

Director of Personnel, Lehigh Coal and Navigation Company

A GOOD deal has been written in recent years concerning the "democratization of industry," a phrase with a variety of meanings, some of them quite revolutionary. The present paper will deal with this same general subject, but from the more conservative standpoint that, without altering the usual structure of organization, the center of gravity in management should be brought lower down, that influences and initiative toward modern management methods should be created at many points instead of at the top only.

For the reason that the writer's interest is in the coal industry, the discussion will be confined to that field with the hope, however, that his suggestions and conclusions may be applicable in other connections.

Before we proceed further, a certain amount of definition seems to be called for. Of course, every producing organization has a head who bosses the job and assumes the responsibility and keeps the works going. That kind of management succeeds under favorable conditions such as unusually active markets which provide large margins of profit, unusually good geographical position with reference to the market, or an unusually good product. Under fierce competitive conditions such as have been experienced in the coal industry since the war, management has come to mean, in a strict, literal sense, making the best of adverse market, labor and natural conditions, not in the spirit of resignation and defeat, but with a view to overcoming those obstacles by active and intelligent measures within the organization itself, by solving the major cost problems at

home. In a recent article Mr. Richard F. Grant, President of the Chamber of Commerce of the United States, put this thought very clearly:

The force that originates method and purposes, that gauges the future and its requirements, brings together the equipment provided by investors and employes and marks out how results can be obtained that will fit the conditions of next month or next year, the force that makes it possible to have something left from receipts after wages have been paid, after bills for materials have been paid, and after investors have been paid, is management.

Doubtless, the first step toward any such type of management is to assume a critical attitude toward traditional methods. Good management requires first of all analysis, and particularly self-analysis. When competition becomes keen enough, those who purpose to install a real management turn from the telescope to the microscope. They resort, in other words, to methods of precision. In many coal organizations it would seem that such management or such analysis would hold out greater hope of producing those few extra tons, and saving those few cents per ton, which will make the difference between staying in business and going to the wall, than any other step.

This is not a plea for "scientific management" of the mines. That term suggests a procedure, the foundations for which have not been laid, if, indeed, the very nature of mining will ever permit a very broad application of its principles. And yet, the coal operator, superintendent, or foreman who gets away, though it be ever so little, from the merely traditional ways and

takes his problems to pieces is, by just so much, conceding something to the scientific way of doing business.

In determining how far intensive management methods may be applied in the mines we must take account of some rather stubborn facts. The chief of these, for present purposes, is that mining, to a greater extent than almost any other industry, is the domain of the "practical" man. His sphere may be narrowed, but he is indispensable. Doubtless the average foreman is more than two-thirds right in his assumption that mining cannot be learned out of books. One probably has actually to handle coal in the veins to understand its geological peculiarities and also to be able to handle the men who handle the coal. It seems hardly necessary to go into detail on this point. There was a time many years ago when the practical man was not only essential, but was the controlling factor in a mining organization. Along in the 70's his limitations became clear and the need recognized of the methods of precision which go with engineering training and methods. Some serious situations arose in keeping straight the boundaries of different mining properties, and in locating the coal in irregular seams. The need for the engineer was accentuated also by a number of serious mine accidents along about this period.

LINKING THE PRACTICAL WITH THE TRAINED

Today the practical man and the trained engineer share the responsibilities, each making his contribution to the industry. One might say that the practical man is contributing art, and the engineer the science. In a mining industry there is a good deal of need in many places for more definitely reconciling these two types of men, points of view and methods of working.

It would seem that an effort should be made to make the practical man a bit more scientific in his own field, and to make the engineer considerably more practical in many of his relationships.

"Making the practical man a bit more scientific" would mean, in a word, that somewhat the same point of view and method which is employed in the domain of the engineer would be brought into the practical man's work. That is to say, production or mine operation should become less a matter of traditional methods and more a procedure based upon analysis.

Now the outstanding representative of the practical viewpoint in the mining industry is the mine foreman. In what measure he and his immediate assistants are converted to ways of order and accuracy depends the degree to which real management will permeate the mine organization. Obviously, the desired result can be brought about, if at all, only by some sort of training, either of present foremen or of their successors.

THE MINE FOREMAN OR EXECUTIVE

To understand what this means requires a brief description of the human material with which we have to deal in this connection. The mine foreman has much in common with corresponding executives in other industries. He starts out with some rather sharply defined strong points, and a number of weak ones. Among the characteristics in the first category would be included an invaluable fund of experience and knowledge gained in actual contact with coal in its original state. Coupled with this experience and knowledge is an admirable resourcefulness which enables him to meet all sorts of new conditions and emergencies. It is probably true that these conditions are not always met in the best and most economical and effective

way, but they are usually met, nevertheless. And because of his experience and knowledge and resourcefulness, the successful mine foreman is a leader of men in an uncommon degree.

On the other side of the ledger are the foreman's weak points. Because he has grown up in close contact with the coal in its natural state, and his working horizon tends to be limited to that particular territory underground where his work happens to be; and because his presence has been required so much in this rather restricted field, he has not had the opportunity to apply principles which have been worked out in other industries. The mining industry is peculiarly isolated. It has developed some peculiar methods of its own. And not only is this true of the industry as a whole, but it is true of localities and individual organizations. In fact, it is somewhat hazardous to say very much about "the industry generally," for nearly any statement that could be made about any of its specific conditions is subject to exceptions.

Because of his peculiar isolation the foreman is often a rather poor organization man, not because of any lack of loyalty, but because the very nature of his work makes it difficult for him to see the common problems of his fellow executives. It is not uncommon to find organization within the mines regrettably incomplete. Many points of danger are not covered with supervision. Discipline is likely to go bad, and the basis of local labor troubles, which in the aggregate tend to become industry-wide, is likely to be laid. In fact, he often inclines to create rather than to solve problems; or rather, to create them in the solving, because of some of the practical short-cuts which seem to him advisable.

Another characteristic of the practical mine executive grows out of the fact that he has had the need of production

drummed into him year in and year out. But along with this drumming there has usually been all too little instruction and counsel with reference to the many factors which form necessary preliminaries to an effective production program. It is not uncommon, for instance, to find a foreman who will permit his rails to get out of alignment, or his roof or timbers to get into a dangerous condition on the plea that his organization must bend its energies to production, even though some of the other factors are neglected. He is apt not to realize that production is the net result of getting all the conditions in the mine properly established.

Unless he is somewhat unusual, he is likely at times to make his own work unnecessarily hard. He has learned supervision of other men as an art, and the methods which he uses are direct and personal. He has usually not learned the trick of managing large numbers of men by impersonal administration methods. So long as this is the case, he puts a limit upon his own advancement, for there are just so many men who can be handled in a personal way. In short, the foreman characteristically is more of a captain than a general. He spends a great deal of time in the mine in this form of direct supervision, and comparatively little time in the study of his job as a whole, thereby becoming more or less one-sided and one-track minded.

RESULT OF LACK OF TRAINING

For this, there is a perfectly good explanation: the typical foreman of today went into the organization in some such capacity as breaker boy (anthracite industry) or door tender. After some years of that he was given an opportunity to drive mules, or to labor in the gangways. Later came an opportunity to "go mining" as a laborer to an experienced miner, or as a "buddy."

After a few years he became a fire boss or assistant foreman, from which position he was promoted to his present job. The job of door tender furnished an opportunity to see and hear a great many things, to store up useful information about mining from stray bits of conversation that floated through the air in the course of the day's work. The more ambitious door boy was not satisfied with what happened to come to him in this way but he actively sought knowledge. If his mind was active he pieced together bits of information, and when an opening occurred he was ready to step into the next highest place.

Now the trouble with the door boy's job or even a miner's or foreman's job is that there is only a limited number of things which one at work can hear and store away and make a part of his experience. It is a slow and laborious way of getting ahead.

It is not strange, under the circumstances, that mine foremen are so often deficient in the power of analysis, the very capacity upon which the main emphasis has been placed in this article. When this deficiency is found in the same man with those positive qualities which have been described, and when so much responsibility is placed upon him as is usually the case, it is also not strange that mine operating organization is often lacking in many of the essentials of good management previously noted.

In many other industries operating executives for a long time have had the opportunity to get their preparation in part from systematized courses of study. The chief opportunity of this kind for the practical mine foreman up to the present time has been confined to those phases of his work which have to do with meeting the requirements of state mine laws with reference to ventilation and other factors of safety in

the mines. This is an extremely important aspect of the foreman's work, but a limited one. Mine management, properly conceived, is a many-sided business proposition requiring careful judgments, balancing of different possible courses of action, forethought concerning the ultimate effect of acts upon cost factors and the functioning of the organizations. The mine foreman with suitable mental attitude and equipment could expand his calling into something much bigger and worth while.

This brings us to the question of method.

PROPOSED TRAINING

The whole matter then comes down to this: Is it possible, in some slight degree, to bring about a condition where the mine organization will catch something of the analytical point of view, the spirit of investigation? If this can be done we shall have taken at least a step toward introducing science into the mining industry at points where it will do the most good. There is such a thing as organizing such information as the door boy gathers at his post and multiplying it many fold, out of the experience of other men. That would be desirable, but it does not go to the root of the matter. What seems to be most needed to be inculcated in the minds of "practical" executives are the basic principles of organization and management and to afford some direction or instruction in applying such principles to the job and the problems nearest at hand. The world to which the foreman needs introduction is not far from home. The materials for his instruction are to be located in the main operating office of his own organization. He needs chiefly to have opened up to him for examination the origins and the consequences of his own acts. There is in such instruction little, if any, of

the abstractions against which the practical mind rebels.

To make this thought clear, reference will be made to the plans of a single large coal company with which the writer happens to be familiar. This company has recently formulated in a rather frank way for its operating men the outstanding facts with regard to its position in the coal industry, its attitude toward the personnel of its producing organization, and in fact a rather wide range of problems which come up in the every-day business of mining coal. A brief outline of the proposed course of training will give the best idea of this procedure:

(1) A chapter on "Meeting the Company's Problems" goes into considerable detail with reference to certain elements of costs, and factors tending to reduce total revenue.

(2) Under the chapter "Production" the several outstanding conditions requisite to maintaining a full and even production schedule, are analyzed, including such subjects as supply and equipment conditions, mining conditions, personnel conditions and safety conditions.

(3) The "Safety" chapter undertakes to get at the root of accidents in the mines, what those accidents cost (both directly and indirectly) and what underlying conditions must be set up in order to prevent their recurrence.

(4) A chapter on "Costs" deals frankly but simply with the functions of business, such as invested capital, revenue and expense. The foreman is shown how operating costs are figured, and then is let into some of the secrets of general expenses, such as taxes, insurance depreciation, obsolescence and depletion. There follow some directions for the practical man with reference to the effective methods of controlling costs.

(5) A discussion of "Supplies and

Equipment" deals with some of the fundamentals of economic use of materials.

(6) A chapter on "Organization from the Foreman Down" undertakes to give some directions and advice with reference to some of the more obvious principles of organization with a view particularly to aiding the foreman to strengthen his executive methods.

(7) "Organization from the Foreman Up" is the title of a chapter largely descriptive of the line and staff organization of the colliery, and of the organization as a whole and of the foreman's relation to it.

(8) The chapter on "Handling of Men" undertakes to relate the human problem in mining to production, costs and safety, and goes into the subject of the selection and organization of men, their instruction, and discipline, and the handling of grievances.

(9) Under "Company Good Will" an effort is made to impress the foreman in numerous specific ways with the importance of contributing his part toward establishing favorable public relations.

(10) A final chapter is one on "Self-Management," the object of which is to help the foreman to organize his work in a systematic manner.

The whole project is frankly experimental. The mere publication of a text should not be expected to accomplish important results, but there is, undoubtedly, a great deal to be said for starting out in a course of training by exposing the man to the facts of his industry. No doubt he will frequently misinterpret them, and possibly abuse some of the new privileges extended to him, but these are risks to be assumed. The ultimate training, of course, comes by doing his tasks in the new ways suggested by an outline of policy. Results are likely to be deferred, but the object striven for is such a large and

comprehensive one that it is worth the waiting as well as the assumption of certain risks.

The thoroughgoing improvements that could be effected, in the event of the success of such methods as have been described, would often materially alter the economics of coal. It is common for both the public and for coal men to think of the cost of production and the price of the product at the market as being regulated almost wholly by conditions largely "uncontrollable" within the industry itself, such as the thickness and accessibility of the seam, wage rates fixed under union conditions

and freight rates determined by a public regulative body. These factors, of course, are basic; but there have been individual companies in the industry which by means of management have removed mountains of natural obstacles, lifting themselves out of the marginal class and avoiding receivership, which in these recent years has been something of an achievement in the bituminous fields. For a coal company to have accomplished such a result in such a way, rather than to have surrendered to the "uncontrollable" conditions, is to have borne something like a full share of responsibility to the public.

A Collective Approach to Problems of Labor Relations in the Coal Industry

or

The Coal Industry, Labor and the Public

By F. R. WADLEIGH

Superfuel Corporation of New York

IN its treatment of the labor question as a whole, it can be truly said, I believe, that the coal industry in this country is far behind other large industries, either in the past or as regards the future, in endeavoring to bring about a permanent, satisfactory solution of labor problems and more healthy conditions in the industry, especially with respect to co-operation of owners and operators among themselves, or with labor and the public.

Present conditions are far from satisfactory from the standpoint of operators, labor and the public; and there have not yet appeared any favorable signs pointing to lasting improvement, or has any apparent desire been evidenced on either side for stability and progress toward definite plans for permanent stabilization of the labor question,—a question of vital, immediate, as well as future, importance. There is apparently no one man or group of men who can command the entire confidence and respect of consumer of the industry as a whole, to whom all concerned would agree to delegate power to stabilize the situation.

Yet the size of the industry, its basic and growing importance in every one's business, commercial and social life, all make its stability and effective energy of essential consequence to the country. The following quotation¹ applies with equal force to the coal industry in this country:

¹Introduction to *Coal and Power*, by Lloyd George.

There is no subject of more importance to the economic well-being of the people of Great Britain than the health of the coal-mining industry and the beneficial use of coal. It is certain that the industry itself is not in a healthy state today and that the nation is not getting anything like full value out of the coal that is raised. The long series of disputes in the coal-mining industry and the condition of armed truce which exists in it today, are proof of the first statement.

Permanently healthy conditions in the coal industry cannot be brought about without the assistance of the consuming public, a fact which has only lately been given some measure of recognition by those engaged in the industry, although other leading and minor industries have long since understood the weight and value of public opinion and have made effective use of it in settling labor problems, as well as in other directions.

Due recognition of the necessity of giving the public some participation in the settlement of industry's labor questions and its right to such participation has been shown by the Federal Government. Certain elements in industry, both employer and employe, have denied that the public has any such right, but the great majority is, I believe, against that position and with the growing increase today in financial ownership of business by the consuming public, whether public utilities or industrial concerns, it is difficult to see any valid reasons for such a stand.

GIVING FACTS TO THE PUBLIC

In common with many others who have given the coal industry's problems some thought, and are deeply interested in its welfare, I believe that one far-reaching, effectual way out of its difficulties, the labor question settlement included, lies in not only taking the public into its confidence, and inviting its assistance, but in a wider diffusion of ownership in coal securities among the public generally. Diffusion in the spread of knowledge of the industry's activities and conditions is greatly needed. Given some financial share in an industry, a person would be more interested in and willing to learn about the industry.

It would be a help if all consumers knew the differences between anthracite and bituminous coal, and some of the conditions attending the production of each. Much of the present trouble between the industry and the domestic consumer today is due to ignorance regarding these differences on the part of the latter. Financial or personal interest in either anthracite or bituminous would stimulate the consumer's desire for understanding the differences between them, and he would be likely to spread this knowledge among his friends and acquaintances.

Those sellers of coal who come into closest personal contact with the public can make such contact of great value to the industry in the settlement of its problems, every one of which, whether in labor, production or distribution, affects the consumer. And the consumer, after all, will be the greatest beneficiary of their satisfactory, equitable solution.

From all outward appearances, it is doubtful if either side in the labor controversies has fully realized or made the most use of the weight and value of public opinion and action in their settle-

ment. In this respect also, the coal industry as a whole has fallen behind other industries. It might with advantage follow the lead of the rail transportation companies and interests which are securing valuable results through intelligent publicity methods. They are also working through the medium of the most efficient and successfully operated trade organization in the world—the American Railway Association—with its recently organized Shippers' Associations.

In defense of the present disunited conditions in the coal industry of this country, it has been stated that in Great Britain the coal industry *is* united, that the Mining Association of Great Britain is 100 per cent representative, as is the Mine Workers' Union; yet there have been and are just as acute and unsettled labor problems there with no greater promise of permanent solution than in this country.

The labor situation in Great Britain as stated is true, but the existing state of unity in the industry there is limited to the colliery owners and operators. Not only is unity lacking in the industry as a whole—owners, wholesalers and retail merchants—but there are no non-union elements to complicate the situation.

To properly approach and handle the labor relations question, in its broad aspects, all of the groups just named should be united, just as all of the different classes of coal labor are, in the so-called "Union districts."

It seems entirely proper to say here that, while the coal industry has not kept pace in its handling of labor problems with other important industries, it does not deserve the harsh terms that have been applied to its activities and dealings by many who, however able and experienced in other lines, knew little about the economic and technical problems of coal, as well as by the

general public and its representatives, self-constituted or otherwise.

The rapid growth of the industry, both as to production and distribution, as well as its importance and value to modern civilization, has been unequaled. There is the more reason, therefore, that in the handling of its labor matters it should endeavor to keep pace with its accomplishments in other directions. The problems which American business and American railroads are going to find the most pressing are going to be, even as they are today, labor problems.²

Coal, in every branch of its activities, is closely tied up with transportation. In fact, the coal industry is dependent for its very existence upon transportation, since without coal the railroads could not function today. Each is, of necessity, deeply concerned in the effectual settlement of the other's labor questions and difficulties, and a study of the problems of one cannot fail to be of value to the other.

WHAT IS INDUSTRIAL DEMOCRACY?

Much has been said and written in this country and elsewhere regarding the bringing about of "industrial democracy," as applied to all industries. This subject has been discussed in Great Britain with especial reference to the coal industry and as applied to mine ownership and operation. As formulated by some labor leaders, "industrial democracy" apparently means either public ownership with close control by the Government, or else placing the management of industry in the

hands of the workers and the Government.

True "industrial democracy," however, as generally understood by well-informed and impartial thinkers and writers, means something rather different: a diffusion of ownership between all employes and the public, where all have some measure of participation in management. Is such a democracy possible in the coal industry? It has been brought into existence in other industries, by individual companies, with successful results, and has been apparently satisfactory to both capital and labor. Is not such a plan worth careful thought on the part of the coal industry's leaders? There would be much opposition and many difficulties encountered in putting any such plan into actual operation, but all can be overcome if the scheme has real, practical merit.

CONSOLIDATION—THE WAY OUT

From sure and unmistakable indications and happenings an era of consolidations in the coal industry has at last arrived,—a period which many have hoped for, in the belief that consolidation will be for the ultimate as well as the present good of the industry. This belief is held not only because of the economies and improvements made possible, *i.e.* standardization in various important directions, elimination of waste and better management, but also because of the decided and definite possibilities of improvement in labor relations, through more concentrated and enlightened management policies, and through the removal of discordant elements, such as trade and personal jealousies and conflicts in distribution, with a smaller number of participants in discussions and conferences, thus making settlements easier to bring about.

Whether any such consolidation plans

² Taken from a review, in *Railway Age*, of a recently published book, "Personnel Management on the Railroads"; a study by the Policy-Holders' Service Bureau of the Metropolitan Life Insurance Company. Its findings and conclusions apply, in great measure, to the coal industry, to whose members, whether employers or employes, a study of the book is recommended; they, as well as the public, will find it not only interesting but of practical value.

include the possibility of employee participation in ownership and management is doubtful, but they do offer opportunities in that direction that are worth careful thought. And why should not such participation and interest, and a larger interest on the part of the public, be considered with such large corporations in other industries leading the way?

It would be difficult to exaggerate the importance of the tendency of large business concerns to try to secure wider diffusion of the ownership of their securities, especially among their own employees. It is easily conceivable that the acceleration and broadening of the movement may be the true solution of the most important and difficult problem of modern civilization.¹

Except in a few minor and comparatively unimportant instances, such a movement has made no headway in the coal industry, but there seems to be no inherent or conclusive reason against it. The bituminous coal industry needs today some strong, far-reaching, progressive movement to help put it in a healthy condition.

Granted overdevelopment, although the amount has been much exaggerated, and a need for some check on future overdevelopment possibilities, labor and its leaders, if true leaders, should be just as interested as owners and employers are in anything that holds promise of betterment for both.

Consolidations in the coal industry will help in this, as in many other directions, if logical. They ought to be on a basis of true commercial value, properly financed and managed, but are not of themselves a panacea for all the ills of the industry.

Some of the possible improvements that might be brought about by consolidation, together with suggestions that will lead to better understanding and

management, might be enumerated as follows:

- (1) Elimination of needless mines and a check on the opening of new ones.
- (2) Weeding out of discordant elements.
- (3) Better management with an active policy as regards personnel.
- (4) Better preparation of product and its more efficient use.
- (5) Keeping the public interested, giving it facts and encouraging it to invest in coal.
- (6) Greater harmony in the industry—producers, wholesalers, retailers and labor, with a united front to all disturbers and disturbances.
- (7) Open and above-board tactics and good faith in all negotiations; giving no excuse for Government interference.
- (8) Working for true industrial democracy, and the elimination of self-seeking agitators and leaders everywhere and in all capacities, whether as employers or employees, or representatives of either.
- (9) Education of employers and employees in the workings of the industry in all branches—financial, operation, sales and use.
- (10) Research and study in economic as well as in technical matters; in labor, welfare, distribution and marketing, as well as in engineering and chemistry, uses, by-products and values.

On the subject of consolidation, it is of interest to have the views of a well-known British trade paper, said to be owned by large South Wales coal and shipping interests.

A writer (editorial) in the *South Wales Journal of Commerce*, discussing Mr. Frank Hodges' suggestions for a revival of the British coal industry, says:

Amalgamations are economically justifiable up to a point. That point is determined by the measure of greater efficiency that can be obtained through the amalgamation of a number of units than by the continued independent existence of those units. But to such amalgamations there is a definite limit. While integrating in their immediate purpose, they always carry within them

¹ *Railway Age*.

the seeds of disintegration, and even in this coal field we have witnessed the use and decline of combines in the short period of little more than a decade. Competition is a more effective guarantee of efficiency in a competitive industry than amalgamations. Taken as a whole, the mining industry of the United Kingdom is the most efficient in the world.

The editorial then goes on to discuss the evil effects of the recent consolidation of British railways (into four systems), and says that its example is one that is to be scrupulously avoided in the interests of the mining industry and of the nation. No one will dispute the statement that there is an economic limit to consolidations. Naturally, if they are not economically and financially sound, their existence cannot be justified. The failure of some "combines" in the past history of the coal industry cannot with reason be used as an argument against their future existence, if organized along different lines.

We have reason, in this country, to believe that consolidations in the coal industry, given straightforward, enlightened and strong management, if they have in themselves sound economic and financial reasons for their existence, afford definite practical and effective means of approaching and settling labor questions in the industry, together with a great opportunity for bringing the public to take a real interest in and to have accurate knowledge, however limited, of the industry; thereby assisting both employers and employes and all who have the true interests of the industry at heart in bringing about better conditions, not only as regards labor questions, but in other directions as well.

FAILURE OF U. S. COAL COMMISSION

The U. S. Coal Commission had a wonderful opportunity for doing a real constructive and lasting service to the coal industry, both owners and labor,

and to the public, but its year of preparation, learning and work has had little actual, practical effect on conditions in the industry, or on its relation to labor generally. Such of the Commission's recommendations and conclusions as have been published or made known have not been carried out, nor, as far as is known, are they in the way of being acted upon—not even by the Congress which created the Commissions. This is due to some extent because a plentiful supply of coal and low prices have brought about a lack of interest in the coal question.

As regards labor questions, the work of the Commission brought forward no well-defined, practical line of action for their answer and judging from public utterances and statements seems to have satisfied neither owners, employers or employees.

A FRANK FINANCIAL STATEMENT

Is not one of the main causes for the various disputes that have arisen and for the difficulties in approaching and handling labor conditions in many industries, the lack of knowledge regarding the latter's financial position? Is it not time for us to decide whether the opinion that any business should be owned and operated entirely in the interest of those financially concerned, should give way to the position that, in order to be entirely successful and avoid all disputes and lack of co-operation, a business or corporation, of whatever size or kind, must be considered as a combination between those financially interested, *i.e.* productive labor and the management that directs the disposal of capital invested, the labor used on production and the sales of the product?

It seems to me that at least careful consideration should be given by the coal industry to the question of adopting some plan in the way of publicity of

costs of operation that would enable the public to judge whether it is being imposed on by either capital, employer, or labor. It *should* work no injury to the coal industry, if individually, or through its associations, or even, if desired, by large individual corporations, it should publish—say quarterly—as is today done by Great Britain's coal industry, summarized statements of costs and profits in each district for each producing district.

Would not such a public statement place the financial and employer side of the industry in the strongest position with the public, which after all is the court of last resort, in any dispute with labor over wages and labor conditions, as well as give definite assurance to the public that it was not being imposed upon?

Such action would greatly tend to make unlikely, if not impossible, the coming of Government control or the so-called "Nationalization" of the coal industry.

It may be argued that the whole problem and its working out is a matter of evolution—that the questions involved will gradually and in time settle themselves. However, evolution works

through human leadership as an instrument as well as through time and environment. It would be well for us to seek such leadership now and make strong efforts to concentrate the best minds available, in and out of the industry, at whatever cost, in an endeavor to bring about the greatest possible measure of union between the warring elements to work out a practical, effectual plan for a settlement that will, without interference with anyone's constitutional or moral rights, and with protection to the public interest, give peace to the industry and enable it to function in such a manner that it can no longer be called with justice "the worst functioning of all industries."

A united, cohesive, amalgamated industry with owners, operators and sellers all working together on broad general lines, with labor and the public participating, without interference from the outside, with free, lawful competition assured each individual—is that a dream or a vision of the future? Dreams have become realities and visions of the future have been potent factors in the development of the world's civilization—moral, economic and technical.

Industrial Management and the American Engineering Council

By L. W. WALLACE
American Engineering Council

THE American Engineering Council was organized by the engineering profession in an effort to provide the profession with an agency through which it might express the crystallized thought of engineers upon national questions in the consideration of which their training, experience and thought would be useful. The engineers have only one motive in supporting and operating such an organization—to meet public responsibilities and to render public service. Twenty-eight national, state and local engineering societies, having a combined individual membership of approximately 42,000 engineers, constitute the American Engineering Council.

The Council was organized in November, 1920, and began its work early in 1921, under the leadership of its first president, the Honorable Herbert Hoover. He was succeeded by Dean Mortimer E. Cooley, of the University of Michigan, who served as president for two years and a half. The third president is the Honorable James Hartness, ex-governor of Vermont, who is now directing the organization.

INDUSTRIAL STUDIES AND FAR-REACHING EFFECTS

In view of the engineering and industrial experience of those who formulated the policies and have guided the activities of the American Engineering Council, it is quite logical that considerable attention should be given to broad management questions. This has resulted in the making of three important industrial studies. However, these studies are not the only

direction in which the Council has busied itself in relation to industrial management. It has also interested itself actively in government operation and national legislation as such have affected industrial management.

I. *Eliminating Waste in Industry*

The first of the three studies relating to industrial management had to do with the elimination of waste in industry, the findings of which were published in book form, entitled *Waste in Industry*.¹ This report disclosed three important facts:

- (1) That a very large amount of preventable waste occurs in American industry.
- (2) The avenues through which the waste occurs or the causes for the waste now obtaining.
- (3) Measures for preventing such waste.

This report has made a profound impression, stimulated serious reflection, and further, stirred leaders of industrial thought to constructive action. As a consequence, within the last four years, a large amount of effort has been expended to eliminate the wastes of industry. This has found expression through the efforts of individual industrial and governmental leaders; through the activity of industrial corporations; and, most significant of all, through co-operative group action. Engineering societies, trade associations, chambers of commerce and government bureaus have held hundreds of joint conferences to

¹*Waste in Industry*, McGraw-Hill Book Company, 370 Seventh Avenue, New York City.

make plans for the elimination of wastes in their own individual and related fields of endeavor. In a recent public address Secretary Hoover said that the annual savings already realized from this movement were not less than \$600,000,000, and so universally accepted were the principles involved that the Department of Commerce has had numerous demands upon it for assistance in connection therewith.

This movement has extended beyond the boundaries of the United States. *Waste in Industry* has been translated into French, German, Polish and Czechoslovak languages. In Czechoslovakia and Poland, national organizations are actively engaged in directing a campaign against preventable waste in industry, commerce and government.

An International Management Conference was held in Prague, Czechoslovakia, last July. Over five hundred engineers and industrialists from thirteen European countries were in attendance. Some twenty-five American engineers took a prominent part in the proceedings. A few months later, a Polish management conference was held—a direct outgrowth of the conference in Prague—and a permanent organization formed to conduct a similar movement in Poland. From the foregoing, it is evident that elimination of waste is a movement international in scope and significance.

II. *Twelve-Hour Shift in Industry*

The length of shift, that is the number of hours worked per day or night in continuous process industries, has been debated at frequent intervals for years. Within the last ten years a number of reports have been issued which either upheld or condemned the twelve-hour shift. For reasons it is not necessary to set forth here, these reports were never generally accepted.

Consequently, they seemed rather to stimulate debate than to lead to a definite conclusion and solution of the problem. This condition indicated a need for an authoritative, unbiased and non-partisan survey of the situation and presentation of facts which, it was assumed, would within itself clear the atmosphere and lead to wise decisions. Subsequent events have proven the wisdom of the assumption.

Through an able committee, the American Engineering Council made a comprehensive survey of the situation. A competent economist and a metallurgist were employed. These men spent many months in collecting information and making a thorough study of the problem. As a result of the findings, the American Engineering Council issued a report entitled: *The Twelve-Hour Shift in Industry*. The essential conclusions drawn were:

(1) There are upwards of forty industries operating more or less completely upon a shift system.

(2) An overwhelming majority of plants which have changed from a two- to a three-shift system, that is from twelve hours to eight hours per shift, have encountered no technical difficulties.

(3) It is not possible to give conclusive data as to the effect, upon the number of workers, of the change from two- to three-shift operation. In many plants the number of workers has increased in proportion to the increase in number of shifts.

(4) The effect of the shorter length of shift on the quantity and quality of work has been satisfactory where good management and the co-operation of labor have been secured.

(5) The evidence is conclusive that the extra leisure time of the men under the shorter working day is used to good advantage.

In the Foreword to this Report, late President Harding said:

* *The Twelve-Hour Shift in Industry*, E. P. Dutton Company, New York City.

I rejoice to note that the conclusions of this great body of experts are identical with those which I have reached from a purely social viewpoint. It has seemed to me for a long time that the twelve-hour day and the type of worker it produces have outlived their usefulness and their part in American life and in the interests of good citizenship, of good business, and of economic stability. The old order of the twelve-hour day must give way to a better and wiser form of organization of the productive forces of the nation, so that proper family life and citizenship may be enjoyed suitably by all of our people.

This clear and convincing report of the engineers must prove exceedingly helpful in showing that this much to be desired result can be achieved without economic or financial disturbance to the progress of American industry.

III. Study of Coal Conditions

The third study made by the American Engineering Council was *Industrial Coal, Purchase, Delivery and Storage*.³ Two factors caused the Council to undertake this study as follows:

- (1) Recognition of the fact that, at frequent intervals, American industry and commerce experience serious interruptions and sustain grave losses because of an inadequate coal supply; and
- (2) paralleling this situation, the coal industry is in an unstable and uneconomic condition.

In this study, the Council endeavored to determine the underlying causes of the conditions referred to and, upon that basis, project remedial measures. The seasonal character of the coal industry was determined to be one of the most significant causes of its condition. This was not surprising, as the seasonal character of the industry is a matter of common knowledge.

Since the remedial recommendations

³Published by Ronald Press Company, 20 Vesey Street, New York City.

made are based largely upon the seasonal aspects, it is well to relate some of the facts herein.

SEASONAL DEMAND AND ENSUING DIFFICULTIES

The coal production curve for the last decade shows that in a typical year the variation in the monthly production of coal is greater than 35 per cent. This does not include fluctuations due to strikes or any other so-called abnormal conditions. The high point in coal output occurs in October; the low in April. This gives the key to the cause of the trouble, namely, *seasonal demand for coal*.

Seasonal demand is responsible for 47 per cent of the idle time in the industry; also for overdevelopment. We have a production capacity twice that of consumption capacity. These two factors are largely responsible for the ills of the industry.

In order to supply the heavy winter fuel requirements of the consumer, the coal mine operator must utilize his capacity to the utmost in the fall. With the drop in demand for his product during the summer, April finds him with an expensive outlay of equipment practically idle—an enormous investment yielding no returns. As a result, both the mine operator and the mine worker feel justified in expecting and demanding a full year's wage for a little more than two-thirds of a year's work. This is waste, the expense of which must be borne by the public.

Seasonal variations in consumption are reflected in unequal demands made upon the transportation facilities of the country, due to the necessity of moving the bulk of the coal supply concurrently with the heavy fall movement of crops. Any measure which operates toward removing the peak loads in transportation will block another avenue of waste, for a more equitable

distribution of the amount of freight traffic will obviate the need for the acquisition of additional railway transportation facilities to satisfy inordinate demands. It has been estimated authoritatively that it would require a \$2,000,000,000 expenditure to provide sufficient additional equipment to meet the peak demands for the movement of coal.

Having established the premise that seasonal demand is the chief cause (though not the only cause) of the unbalanced condition of the coal industry, the logical remedial procedure is, if possible, to correct that factor first. It is the consensus of opinion of all who have studied the problem carefully that storage of coal by the consumer during the first six months of the "coal year," *i.e.* April through September, will, if practiced generally, alleviate the irregular operation of the coal industry by equalizing the demand; it will remove the peak loads in transportation by making possible equal monthly deliveries of coal throughout the year; and finally, it will do away with frequent panicky market conditions and coal shortages.

A remedy, to effect a cure, must not involve other ills as serious as those it seeks to eliminate. Therefore, before recommending a general policy of storage of coal, it was necessary to study the difficulties, real and imaginary, incident to the adoption of such a plan. Perhaps the greatest danger signal flashed in the path of advocates of storage of coal is that of spontaneous combustion. These words suggest a whole train of deterring ideas: loss of heat value, degradation through breakage, coal-pile fires, etc., all very real difficulties if they must inevitably follow the storing of coal. But it has been demonstrated, through careful laboratory research and by practical experience, that these ills need not

attend the adoption of the plan. The conclusion is that if simple and inexpensive precautionary measures are followed, the loss, if any, from spontaneous combustion, heat loss and breakage, is inconsequential.

The next in importance of the difficulties advanced as an obstacle to storage is that of its relation to transportation. Car shortage has been given as one of the causes of instability in the coal industry. Bituminous coal constitutes one-third of the total freight tonnage handled by the railroads of the country; therefore, any change in the movement of coal would seriously affect the transportation and, hence, the economic life of the nation. In the report, this subject is fully covered. Briefly, the conclusions are:

(a) It has been demonstrated that the railways are equipped to transport all the coal required for domestic consumption and export, provided that coal is available and that the demand for its movement is somewhat uniform throughout the year. Transportation facilities are even ample to meet the needs when the requirements are considerably above uniform demands. Cases of loss of time at the mine and failure to obtain coal, due to car shortage, have been caused by two factors:

- (1) An inordinate demand for coal, due to a panicky market;
- (2) A demand for a large transportation of coal coming simultaneously with a heavy fall movement of crops.

(b) A large fraction of the cost of coal is represented by cost of transportation. It is through the inability of railroads to meet abnormal shipping demands at those times when the market shows signs of instability and the rush for coal begins that a part of the pyramiding of prices takes place, and the extreme fluctuations occur which do so much to unbalance the industry.

(c) The railroads, according to best authorities, use 28 per cent of the total bituminous coal produced in the United States. Therefore, coal for railway consumption comprises approximately 11 per cent of the total freight tonnage. Railroads control the movement of the coal they use, and if they so chose they could store large quantities of this coal at different points on their lines. This would tend to balance the total freight movement and to diminish the likelihood of uncertainties of coal deliveries.

After considering the question of spontaneous combustion and transportation, the next question that arose was: How much coal should be stored by the consumer?

The answer to this question is given in terms of the per cent of annual consumption. It would have been possible to set up an arbitrary amount as recommended for storage during the first six months of the coal year (April-September). However, in view of the importance of this phase of the problem, it was deemed advisable to derive the per cent after an exhaustive study of consumption requirements, storage capacity, and receipts of shipments for different localities throughout the United States. Accordingly, a field investigation was made and data, sufficient to evolve the desired formula, were obtained from over forty communities distributed over the entire United States.

The analysis showed the exceedingly interesting fact that in a large number of cases coal accumulated in storage during the fall and winter months was taken from storage during the spring and summer—a practice contrary to the best economic policy and one which produces the greatest activity on the part of the mines, dealers and transporters during the months when the cost of operation is the highest. Instead there should be a uniform demand

upon the mines and the railways throughout the year. Coal should go into storage during the spring and summer months. The committee made an analysis to determine whether or not this could be done. The analysis showed that, on the average, from 7 to 8 per cent of the annual consumption is always carried in the coal bins to meet ordinary delays and unexpected requirements. It was further ascertained that if an additional amount of from 8 to 10 per cent of the annual consumption were placed in storage during the months April to September inclusive, there would be a sufficient amount in storage to provide for winter requirements. Therefore, all the storage required to make a uniform production and transportation schedule possible is approximately 18 per cent of the annual consumption. This would mean that as of October 1 of each year there would be about 83,000,000 tons in storage. On September 1, 1923, there were some 63,000,000 tons in storage.

From this and an analysis of the storage facilities now available, it is evident that the 83,000,000 tons could be easily stored and without much additional expenditure. In the light of these facts, the committee recommended that users of coal purchase coal upon a yearly contract and specify that the coal be delivered in equal amounts per month. For example, if a consumer uses 60,000 tons per year, he should have it delivered at the rate of 5,000 tons per month. This would automatically achieve the following:

(a) The consumer would always have the necessary amount of coal for operating purposes in his bin.

(b) He would always have 7 or 8 per cent of his annual consumption in his bin as a protection against unexpected delays or requirements.

(c) There would accumulate during the months April to September inclu-

sive, a sufficient amount of coal to meet the increased requirements of the winter months.

(d) He would not be subjected to the delays and expenses incident to a panicky and uncertain market and to the hazards of winter transportation.

Equipment is available to meet any storage situation at a cost of from a few cents to not more than \$2.50 per ton of capacity. The cost of storage per ton, including fixed charges, maintenance and operation expense, interest on investment in coal, taxes and insurance, is in most instances \$.50 to \$.75 per ton per year for large plants and \$1.00 to \$1.50 for small plants of a few thousand tons or less.

If all large consumers and dealers in coal would make annual purchases on uniform monthly delivery bases, the following results could be confidently expected:

(a) Coal mines could inaugurate and maintain a regular production schedule which will

- (1) Eliminate overdevelopment and the snowbird mine.

- (2) Keep miners regularly employed and remove many serious labor disturbances.

(b) Carriers could plan definitely as regards both schedules and equipment, for a uniform movement of coal which will

- (1) Make cost of transportation less.

- (2) Make delays less frequent.

- (3) Make less interference with the movement of other commodities.

- (4) Reduce production delays in industry due to inadequate and inferior coal supply.

(c) A reduction in the price of coal will be made possible by means of regular schedules of production and transportation, and by elimination of peak demands in winter months when all costs are highest.

It is clear that no one group associated with the production, transportation or consumption of coal is wholly responsible for the ills affecting the coal industry and the economic and social distress which these ills give rise to. No one group, unassisted, can effect a cure. Co-operation is the only foundation upon which remedial measures will succeed. Only consumers of coal can initiate the vitally necessary cycle of changes.

IV. *Work for the U. S. Patent Office*

The American Engineering Council has dealt with problems of management in other directions than those named. It is frequently active in relation to national legislation of an engineering character which means, also, of an industrial character. An illustration of this is the attention given to matters affecting the U. S. Patent Office.

The patent system of the United States Government is the backbone, the heart-throb, of American industrial, agricultural and commercial progress and stamina. That the Patent Office pass upon applications for patents accurately and expeditiously is of great importance. Slow and inaccurate performance may mean and often does mean that progress is impeded and disastrous losses experienced. Recognizing this, the American Engineering Council, in co-operation with other agencies, secured increased personnel, appropriations and space for this most essential activity. The Council is now represented upon a committee, appointed by the Secretary of the Interior, which is making a thorough study of the organization and operation of the Patent Office.

The American Engineering Council has collaborated with other national groups in eliminating waste, due to business cycles and unemployment;

seasonal work in the construction industry; wasteful and improper use of forest products; chaotic organization of the Departments of the Federal Government, and similar problems.

It is the purpose of the Council to continue its activities in the directions

indicated. In thus bringing engineering training and experience to bear upon the solution of national problems, the engineers of the United States are endeavoring to meet their responsibility as citizens, to render service to the community, state and nation.

The Work and Aims of the Taylor Society

By PERCY S. BROWN

President, Taylor Society; Works Manager, Corona Typewriter Company, Inc., Groton, N. Y.

IT was among engineer-trained executives that consciousness of the management problem first began to find expression in what has come to be known as "the management movement." During the '80s the development of big-scale industry was under way and brought with it problems centering about the supervision and control of operations. The analytic engineer-mind first perceived and attacked the problem. In 1886 Henry R. Towne clearly set forth its nature in the famous paper before the American Society of Mechanical Engineers, *The Engineer as Economist*, and for nearly a decade thereafter meetings of the American Society of Mechanical Engineers and technical engineering journals offered the only forum for study and discussion of the management problem, in which there was a growing interest. This was a natural center for the beginning of interest in management. The problem had been created by big-scale enterprises utilizing labor-saving machinery under division of labor, and it was one of learning how to manage the use of machines—of production. It was not then a problem of selling, for America was uncovering abundant new resources, population was increasing rapidly, purchasing power was increasing more rapidly, and there was a continuing sellers' market. The management problem first took the form of complications in the utilization of machinery, and it was inevitable that the first group to be challenged by it should consist of the very men who were inventing and installing equipment, and endeavoring to teach industry how to manage it.

ORIGIN AND LINEAGE OF TAYLOR SOCIETY

But all engineering sciences were growing rapidly during this period, and by 1910 the American Society of Mechanical Engineers was confronted by the problem of settling the scope which its resources would permit its work to take. It was decided that the greater service would be rendered by emphasizing pure engineering, and consequently study and discussion of management found its opportunity restricted.

There being no other forum, a small group of about a dozen members of the A. S. M. E., led by such men as James M. Dodge, Frank B. Gilbreth, Robert T. Kent, Conrad Lauer, Carl G. Barth, Morris L. Cooke and H. K. Hathaway, began to meet regularly for continued, more intensive, discussion of management. There was at the beginning no formal organization of a "society," but in the winter of 1910-11 the organization was made formal and the Society to Promote the Science of Management came into being. This formal organization was stimulated by the marked general increase of interest in management caused by testimony concerning the achievements of scientific management at the Eastern Rate Case Hearings, and more particularly by the fear that, because of the sensational nature of the testimony concerning results, there would be a grand rush by industry to "get efficient quickly," and the very engineering technique which had brought the results would be neglected and eventually lost. The group decided that it was a service

obligation for them to strengthen their position as defenders of the engineering point of view.

The Society to Promote the Science of Management continued to hold meetings of a more formal nature, and in December, 1914, began the publication of a periodical bulletin. The quality of its discussions and published articles attracted some attention and caused a gradual and unsensational increase in membership, so that by the outbreak of the war, in 1917, the membership was something over 100. No campaign for membership increase was undertaken, the policy being to preserve the homogeneity of point of view and technical approach towards management problems, and to let membership increase be the result of natural attraction of like-minded executives and engineers.

During the war nearly all the members became absorbed in one way or another into the war machine, and the society became quiescent. But immediately after the Armistice activity was resumed and on a larger scale. Perceiving the magnitude of the industrial problems which would inevitably result from maladjustments left by the war, and believing it had something to contribute to the solution of those problems by emphasis of the engineering approach, whatever the area of the field of management in which the problems might arise, the society organized deliberately for larger service, established a New York office with a full-time executive, and, in honor of the pioneer of engineer-executives who had died in 1915, changed its name to the Taylor Society. Since that time its membership has gradually increased to some 800.

PURPOSE AND RANGE OF INTEREST

The above account of the origin and lineage of the Taylor Society is impor-

tant, as it makes more understandable the purpose and methods of the society. In the first place, it is the descendant in direct line of that group of engineer-executives—such as Henry R. Towne, Oberlin Smith, James W. Dodge and Frederick W. Taylor—who first perceived the emergence of a management problem in American industry. In the second place, it inherited from that group and cherishes the engineering point of view and method of attack on management and other social problems. In the third place, descended from men who had been trained as scientists and who valued the search for truth for its own sake, it is without ulterior motive or special interest, and is not afraid to consider any problem within the scope of its general interest, and particularly considers all facts, whatever their source, bearing upon any problem which falls within its field. These three things, I believe, together with certain features of organization and methods of work resulting from them, are the outstanding characteristics of the Taylor Society.

Faithful to these traditions, it has fearlessly searched for, appraised, and put on record the most progressive and noteworthy thought and practice with respect to every phase of management which has assumed importance as changing industrial conditions have defined importance. Its first inquiries were concerned with production, for on a sellers' market that was then the important problem of management, and the Taylor Society believes that fundamentally and in the long run production will always be the most critical management problem. But when complications of big-scale industry caused industrial relations to become a problem of outstanding importance, the society considered it in a characteristic manner. It was the Taylor Society which promptly gave such progressive

thinkers as Robert Valentine and Robert Wolf a forum, and which more recently established real contact between psychologists and industry. And when the buyers' market generated by the war came upon American industry, the Taylor Society promptly made inquiry into two phases of management which emerged as of major importance—general control and selling. Nowhere are there to be found records of more searching inquiry and more fruitful suggestions concerning the function and technique of co-ordination and the function and technique of selling than in the published bulletins of the Society.

What may result from the engineering method of approach to such a problem as that of industrial relations? That method, distinguished by insistence upon ascertainment and measurement of all the facts pertinent to any problem, as applied to the problem of industrial relations has unmistakably established two conclusions: that the human element is as real a factor in management as is the mechanical and cannot be disregarded in any adequate system of management; and that the regard for the human element in any system of management must itself be upon a factual and not an emotional basis. Too many of the studies of industrial relations during the past ten years have been dominated by emotionalism and have resulted in ill-considered methods of personnel management. In too many instances personnel management has been assumed to be something separate from operating management, and personnel departments have been plastered onto instead of incorporated into operating organizations. Fortunately most of these mushroom-growth personnel departments were eliminated by the depression following the war, and industry is now able to approach its problem of

industrial relations anew along those sounder lines which make good or bad industrial relations a function of good or bad policies and methods of operating management. It is in the process of engineering its policies and methods of operating that an enterprise is engineering its conditions of human relations. This was noted recently by Miss Mary Van Kleeck, of the Russell Sage Foundation, in the following words:

My experience began with what is called the human element in industry, and I saw it first outside the shop in the community. In the lives of wage-earners, particularly women in industry, I saw the effects of long hours of work, unemployment and low wages. In the search for remedies I was led back into the causes of these conditions in the shop itself, and nowhere did I find so many questions in process of being answered as in the Taylor Society. Not the final answer but the process of discovering the answers was for me the big contribution of this group . . . my interest in the Taylor Society is not directed toward challenging the technical engineer to give attention to problems of human relations. I am not worried about that, because if he is a good engineer he cannot fail to contribute to human relations. I am concerned rather with the other end of the story. I am eager to have those people who see in the community the present disastrous results of industrial organization realize how the art of management in the shop can fundamentally change those social conditions in the community. The Taylor Society can thus interpret management to the group who are seeking to construct a better community.

ENGINEERING POINT OF VIEW

This faithfulness to ancestry has imposed upon the Taylor Society certain restrictions which it has recognized and accepted. In the first place, insistence upon the engineering point of view and method of attack upon problems has permitted only modest

growth in membership, for executives whose background is that of frontier conditions—American industry is just emerging from frontier conditions—come slowly to appreciate the engineering point of view and methods. Yet it is interesting that the membership of the Society is today made up chiefly of executives who have not had engineering training and have not been concerned with what are generally regarded as engineering responsibilities. That means, of course, that the mental attitude identified by the term engineering is independent of particular training, and it means also that an increasing number of American executives are developing the habit of approaching their problems in an engineering fashion.

That the engineering point of view and technique should gradually appeal to an increasing number of manufacturing executives was to be expected. But it is somewhat surprising to find that its march has been so rapid as to excite the interest even of executives of merchandising enterprises. The organization under the inspired leadership of A. L. Filene, the Boston merchant, of such an enterprise as the Retail Research Association a dozen years ago, was a venture in organizing for an engineering attack on problems of retail management. And recently E. A. Filene, the other of the two sons of Wm. Filene's Sons Company, has in his book, *The Way Out*, specifically declared the necessity of the engineering method in solving our industrial problems. I cannot refrain from quoting the following:

American business has reached its last frontier. . . . As society develops the pioneer must be succeeded by the engineer. . . . The business men of tomorrow must have the engineer-mind. We would better turn our energies to the urgent job of substituting the engineer-mind for the pioneer-mind in the American business of the future.

That is exactly what the forebears of the Taylor Society saw, and what the Taylor Society has made it a mission to persuade American industry to see.

DEFINITE PHILOSOPHY

Again this faithfulness to ancestry has imposed limitations in growth for the reason that the engineering point of view demands the acceptance of a definite philosophy and technique of management. One cannot have the engineering mind and fail to systematize his thought and methods. Therefore the Taylor Society has accepted, in a liberal way, the only philosophy of management which research has yet enabled industry to formulate—the Taylor philosophy. It is either that or no unifying system of thought—no one has formulated an alternative. Therefore, although subscription to the Taylor philosophy is not a condition of membership, the very fact of the Society's acceptance of a governing system of thought in its investigations of management problems, and in its appraisal of management experiments, is a deterrent to rapid and spectacular increase of membership. Some executives do not desire to accept consciously, however tentatively, any system of thinking; and particularly some do not desire to be identified with the Taylor philosophy because of failure to perceive its essential nature and separate that from incidents of controversy during the early days of its formulation. The Taylor Society recognizes all of this, accepts the consequences of temporary restrictions, and goes seriously on its way, for it is "bullish" on the value of the engineering point of view and its ultimate acceptance by American industry, and on the spiritual and intellectual strength which comes from guidance by a definite system of thinking which contains within itself the principles of adaptability to changing

conditions and the requirements of new information.

METHODS—POSSIBLE

The characteristics of the Taylor Society which have been described naturally influence its organization and methods of work, and cause them to be different from the organization and methods of other societies having a similar and equally worthy purpose. The operations of a management society may be distinguished in the large by the manner in which it combines and emphasizes certain possible elemental operations. The most important of these elemental operations are as follows:

A. Investigation

1. Genuinely scientific research through a staff of paid experts.
2. Group organizations of the membership for comparison of experiences.
3. Discovery, discussion and appraisal of the results of significant research and experiments by specialized research organizations and progressive industrial enterprises.

B. Service to Members

1. Meetings

- a. Carefully organized programs featuring selected advanced ideas and practices.
- b. Carefully organized programs featuring general participation of members and comparison of their experiences.

2. Publications

- a. Containing selected and edited material derived from meetings of the type B1a and similar material from other sources.
- b. Containing articles reflecting records of general membership experience derived from meetings of the type B1b.

3. Advisory and Information Service

- a. Information related to particular problems rendered to members in response to inquiries by correspondence and personal interview.

4. Miscellaneous Service

Such as assistance in securing particular types of personnel for member's organizations, introductions for those on tours of inspection, etc.

C. Public Service

1. Promotion of and participation in programs of a public nature, involving management problems, undertaken for the public welfare.

It is obvious that to perform all these operations adequately would require large resources and a considerable executive staff, and no management society finds itself in that happy position. So the problem of organization and methods consists of choosing and emphasizing elemental operations such as those enumerated above.

METHODS—ADOPTED

Because of its moderate size and limited resources the Taylor Society has had to choose carefully. The choosing has been influenced also, obviously, by the society's origin, antecedents and point of view.

In general it has chosen to apply its limited resources to the fields of investigation and service to members rather than to the commercial phase of increase of membership with corresponding neglect of the investigation and service activities.

With respect to investigation it has recognized the impossibility of expensive genuine research through a staff of its own. It has emphasized, in the work of the *national* society, the dis-

covery, discussion and appraisal of the researches of specialized research organizations and the experiments of progressive enterprises. On the other hand the investigation involved in comparison of experiences of members is emphasized in the work of constituent regional sections.

This is reflected in the programs of meetings and in the *Bulletin of the Taylor Society*. The meetings of the national society feature the presentation and discussion of new and progressive ideas and practices, whether by members or non-members, and the *Bulletin* features articles of a similar nature. The more frequent meetings of a regional section, on the other hand, emphasize the consideration of problems, practices and experiences common to the membership of the particular section.

The advisory and information service is an experiment and time will be required for members to learn to use it and for the society to learn how to render the service. But it is growing slowly; members of all classes—old and young, engineers and executives—are utilizing the executive staff of the society as a center of information bearing on their problems. As the fund of information which members may tap increases in quality and quantity—and the very nature of the operations of the central office of the society causes it to

increase—members will more and more utilize such facilities of the society.

The society has not hesitated to cooperate with others in programs motivated by the desire for improvement of social conditions where such improvement has involved problems of management. A noteworthy instance was the publication of Horace B. Drury's study of the three-shift system in the steel industry, a study the influence of which, combined with the influence of other similar studies, brought about a significant change in management methods in the steel industry. Another instance, of international public service, was the acceptance by the Taylor Society of detail labors involved in the organization of the effective contribution of the Committee on American Participation to the Prague International Management Congress in 1924.

The Taylor Society is interested in advancing sound thinking concerning the management problem throughout its entire range, in promoting understanding of established principles and discovery of new principles, and in assisting its membership to the command of an engineering technique of investigation and a flexible technique of management derived by that method of investigation. It welcomes to membership all who have become convinced that "the business men of tomorrow must have the engineer-mind."

The Work and Program of the American Management Association

By W. J. DONALD

Managing Director, American Management Association

A FREE interchange of views—many of them quite antagonistic—on management problems, to the end that business executives present and potential may grow in power to solve their own problems as they come up, is the purpose of the American Management Association.

It has no creed; it does not make its members subscribe to any "fourteen points"; it is not promoting any particular plan; it does not pass resolutions. There is nothing in its form of organization or in the spirit of its work to dam the free flow of thinking. These are the essentials of management education as distinguished from propaganda.

The scope of the subject matter covered by the Association is quite wide. It covers the management of finance, production and sales—not only management in the limited sense of "execution" but also policy making. It covers not only the problems of line executives such as sales managers, treasurers and works managers and their superior and junior executives, but also the problems of staff or advisory executives such as sales research directors, personnel directors, planning directors, production engineers, office managers, etc. General management and administrative problems such as budgeting and organization also come within the Association's scope.

SOLVING MANAGEMENT PROBLEMS

Emphasis has been laid on the "human factor in commerce and industry." This has a history. From 1913 to 1922 the National Association

of Corporation Training (Schools) emphasized a solution of management problems in terms of employe training—especially by classroom instruction. From 1919 to 1922 it was rapidly becoming apparent that, to quote W. W. Charters, 85 per cent of training is done not in the classroom but on the job, and that it is the responsibility of every line executive assisted wherever possible by an adviser on training methods.

Meanwhile, the National Association of Employment Managers, later called the Industrial Relations Association of America, was studying the problems of selection and placement of employes and labor relations generally.

The two associations were overlapping and competing.

In 1922 the two were combined as the National Personnel Association. This step recognized the unity of the personnel problem in management and that selection, training, placement, etc., are simply different parts of the same problem and to a certain extent different but supplementary approaches to the same problems.

In 1923 the Association established divisions for each of office, production and sales executives, each to consider personnel problems peculiar to the office, the factory or the sales organization.

Another development of 1923 was a change of name to the American Management Association. This step was due to a growing recognition of principle set forth at that time in the following statement by the Board of Directors:

Personnel work is an integral and inseparable part of management interwoven into all of the efforts and activities of the production and sales departments and of the office, and we believe that the line executives are concerned directly and must deal at first-hand with the problem of human organization, including among other things leadership, and that, while they can increase the effectiveness of their personnel administration by employing a personnel man in an advisory capacity or by establishing a personnel department, yet they cannot divest themselves of their responsibility in this connection simply by so doing.

We also believe that the advisory personnel executive must have a basic knowledge of management in general, in addition to a complete knowledge of the technique of personnel work in particular and that his recommendations will be of value in the degree to which they complement and dovetail with other phases of the science of management.

The Association is organized on the principle that the human problem in commerce and industry is a major problem and that personnel administration is a responsibility of the line executives assisted wherever possible by the advice of staff executives trained and experienced in this field of activity. In short, without in the least denying the validity of other points of attack, it approaches the study of the whole management problem in terms of human organization.

It studies problems of human organization—whether in the shop, in the office, or in the sales department—whether in the field of manufacturing, or banking, or insurance, or retail trade, or transportation or elsewhere.

DIVERSITIES OF THE HUMAN PROBLEM

This was a far-reaching step, for inevitably it forced the Association to recognize that the solution of the human problem in commerce and industry has wide ramifications. The regularization of employment, for instance—one of the most vital human problems in industry—cannot be solved

unless there can be a regularization of production. This in turn demands either a regularization of sales or the development of technical methods that will release the production from the immediate variations in sales. It calls for budgeting and for adequate organization, for efficient management, both within and without the company. Not least important is the necessity for adequate and proper financing without which what might otherwise be a profitable business might not be able to meet this week's payroll.

This point of view was very aptly expressed in a recent article on the Association's convention which appeared in the March, 1925, number of *Administration*—as applied to production, as follows:

Responsible executives drawn from all departments of industry were represented to perhaps a greater extent than at any similar convention in the past. The presence of these executives and their active participation in the program emphasized the growing tendency to consider personnel administration as a definite function of management. Operating officials are coming to look upon the industrial relations expert as a staff specialist employed to help them solve problems which they now acknowledge as being directly hooked up with their own jobs. Personnel directors and counsellors, on their side, have made impressive advances in mastering the essentials of economics, of business management and of finance. The co-operation and mutual understanding which have resulted from this state of affairs have worked to the advantage of all parties in industry.

Along with this recognition of labor administration as an essential part of general management, there is growing up—gradually, it is true—a policy of giving unified consideration to all subjects having a bearing on labor relationships. The sales manager no longer ignores conditions of employment in the

factory; the financial expert is giving thought to stability of work; the public relations adviser has learned that his efforts are gravely hampered if labor conditions in his organization fail to win public approval.

As additional evidence of this conception of the inter-relations of the human problem in commerce and industry, the American Management Association absorbed the National Association of Sales Managers in February and established a Financial Executives Division in June of 1924.

THE MOTIVE—SERVING THE PUBLIC

Unquestionably the motive back of the leaders of the Association lies in the desire to help to solve one of America's most pressing problems—the problem of relations between employers and employees—or the problem of class conflict. I believe that most of the leaders—indeed, most of the members also—would subscribe to the following statement of the case by Mr. Samuel A. Lewisohn, President of the Association:

There is a healthy demand for more and cheaper goods, stimulated by the higher standard of living which higher real wages have made possible. The industrial cycle is well speeded up and forward-looking executives have realized that the proper functioning of this cycle is dependent upon a well satisfied body of citizens who are at the same time workers and consumers. In order to meet the

increasing demand for goods and for higher wages which is inherent in this process, we must perfect our management methods.

We believe that the responsibility for meeting this issue rests squarely on those who are charged with the management of business organization. Business executives are in the advantageous position of being at present probably the most influential factors in our country's progress.

Specifically, this new stage in management includes improved methods of selecting, placing and training workers, methods of compensation that promote production, and means of planning and controlling the production process to eliminate wastes of labor and material. In addition, it includes establishing an understood relationship with the workers which tends to remove any latent antagonism and to secure their full co-operation in production, increasing the efficiency and reducing the cost of marketing, correlating sales, production and finance through budgetary control, and the study of market conditions.

A body of management knowledge is being accumulated which each business man may adapt to his own needs. In adding to this knowledge and in applying it, each to his own business, executives will be making a direct contribution to the nation's welfare.

It is the purpose of the American Management Association to make a contribution that will help American business men to solve their problems, and by helping them solve their problems, help to serve the American public.

Business Management and the Professions

BY HENRY S. DENNISON

President, Dennison Manufacturing Company

IT may be a little early as yet to claim that there is a profession of business management. Certainly to make the distinction of professional and non-professional business management is to make a distinction not among men but rather amongst the mixture of motives which actuate each business manager. One who in his selling may act up to the highest professional standards, in his buying may act upon the most barbaric, devil-take-the-hindmost motives with no regard to honorable deencies or his own goodwill account. But gradually through this partial action upon all business men there are two groups formed: the fighters and builders, the business warriors and business engineers.

Now engineering is a profession, through the application of science. Can business management ever become really an engineering job? To my mind powerful affirmative evidence is offered when one considers the present status of industrial management in the light of an analysis of what constitutes a profession and in the light of the history of the slow and ragged growth of some of our highest professions of today.

APPLYING SCIENCE TO THE PROFESSIONS

For science is no stranger to the business man, though as yet he has seldom called upon it to aid him in understanding his human problems. Economic history, statistics, industrial psychology are steadily developing to his use as auxiliary sciences, offering clearer understandings upon such factors as trade

restrictions, the swing of the business cycle or the special fitnesses of applicants for employment. Parts of his own job are being marked off, functionalized and lifted into science-based professions like accountancy; while, passing through their embryonic forms as all such specializations must, are many occupations like purchasing, advertising, traffic-routing and labor management. As in medical practice there is scarcely an organ of the body which has not its devoted student, so in the world of business, specializing may go far; and each auxiliary profession, as it comes to face earnestly the real difficulties which give worth and dignity to its pursuit, will examine more and more insistently some commercial practices of long acceptance.

Thus, years ago medical science, chemistry and astronomy began to question the *à priori* reasonings, centuries old of necromancy, alchemy and astrology and by careful observation and rigorous testing of hypotheses began to make headway against the active and powerful devotees of the semi-poetic, semi-philosophical notions and the old wives' tales which had been repeated so early and often as to seem most rational. The undoubtable conviction that a philosophers' stone was to be found, and the delighted satisfaction in the cycles and epicycles of the Ptolemaic system must have led many well established professors to dub him a mere theorist who failed to accept them wholly. A firm adherence to gruel baths, to boiling oil for gunshot wounds, and to cupping for everything, was for centuries demanded from such doctors

as did not want to be called radical or worse. But the insistent questioners finally prevailed and such practices were finally seen to cost too much in life, in the search for truth, or in the material forms of wealth.

The business man, likewise, is finding ready-made notions too costly for the comfort they afford. From the history of the pure sciences he is learning to respect patient impersonal study of problems. From the applied sciences he is learning how consciously—as in the past he has been wont unconsciously—to make commonsense use of “all the facts yet available,” and to set limits to his dependence upon intuition. He must turn to the best in the medical profession to discover how to combine science and commonsense and something higher than either, into an art.

He has already found out that an intellectual training—indeed a special post-graduate training—is of dollars and cents value; though to be sure, the theorists and pedagogues have rather forced this discovery upon him. But at a parallel stage of development, by making them see that apprenticeship—mere learning in the office—left too much to be desired, the pedagogues had to force the doctors and lawyers of past generations to get behind their medical and law schools. And when, early in the 19th century, the first proprietary schools of medicine made their appearance, fresh troubles beset the educators. With only a professor or two, a small investment and large profits, these get-wise-quick schools ground out a product which made the better trained physicians resort to unworthy expedients to stand the strain of competition. But by 1900, under the persistent attacks of the more sincere teachers and leaders of the profession, the schools run for profit were already beginning to disappear. The better schools began correspondingly to flourish,

many of them raising their entrance standards, some lengthening their courses, all increasing their equipment. In law the growth of proprietary schools came after the Civil War and followed a very similar course. Apparently in its earlier years professional education gets as its measles the quick-quack-degree dispenser—the school poorly equipped, taught by men whose sole motive is profit, and recruiting students among the semi-educated by means of mendacious advertising.

Good pedagogical engineering among our growing business schools should be able to avoid the occurrence of a similar disaster and to forestall the dilution and adulteration of the worth of the M. B. A. degree too likely to come *if human nature is allowed to take its course*. Such foresight is greatly to be hoped for; business management has suffered enough from quackery to be spared disappointment of its present hopeful prospects.

But even if human foresight should again fail us and university training for business administration be crowded out of good standing by the gilt certificates of proprietary schools it can be only temporary. For the business situation has become much too complex and hypersensitive to let us rest easy if our life and progress depend upon the hunches and hurrys of a “natural” *laissez faire* economy. Nature's methods are based upon high mortality and quick turnover,—the individual case counting for nothing, progress being scored in the average and the by-and-large. In truth we have already built up a man-made machine so involved that it cannot succeed under a trial-and-error, survival of the fittest régime; it cannot do without trained business engineers as its tenders; as soon “let go” and ask nature to run New York's telephone system.

Just here, in the indispensability of

the engineer, the captain of industry in spite of present difficulty finds his greatest hope of future salvation. An engineer must base his cases upon science and commonsense; any power or authority he has may help if his reason has found the right way; but no force of authority will answer for him in place of correct analysis and induction. In the engineer the captain of industry finds the beginning of that insistence upon truth and that suspicion of mere might which and which only can break through the vicious circle of strife surrounding him.

In view of what he expects of himself and what is expected of him, the engineer cannot measure his success solely by "results" in their usual business meaning, by his financial return or the degree to which he has his own way. Some other measures of his worth must have a part in his final self-valuation, some estimate of service to his fellow man and of contribution to the fund of human knowledge. No engineer would neglect so useful a force as the profit motive, but would limit its sovereignty by placing greater emphasis on the motives enhancing self-respect, on service and scientific consistency. The financial measure of success—the profit motive—enters into his calculations as it enters into the doctor's, as a *part* of his consideration, not as its beginning, middle and end, not as its single control. Single controls are notoriously unable to make the adjustments which maintain a proper balance of forces and interests and avoid losses through internal frictions and strife. It is the unconditioned and hence too exclusively self-considerate nature of capital's control since the industrial revolution which may be held largely accountable for the present strife.

SIGNIFICANCE OF BUSINESS CODES

But in much the same sense that an absolute monarchy simplifies govern-

ment, the predominant influence of financial return and of the ambition for position and display made possible by money, simplifies life; whatever course makes money and keeps out of jail can presumably be chosen. Joint control by several motives on the other hand leaves such simplicity far behind and begins to demand rules of good behaviour—codes of right action, codes of ethics. It is by no means without significance that the formulation of such codes is being very widely attempted.

In the course of its work the Committee on Business Ethics of the U. S. Chamber of Commerce has collected more than fifty codes from among associations of American business men.

Take advantage of no man's ignorance and see that employees are truthful and straightforward and do not misrepresent nor overcharge the confiding.

It is an absolute essential in honorable competition that we prove ourselves as honorable in every particular as we would have our competitors.

When a printer is offered work which he cannot do, his rule should be to decline it and refer his customer to the office that can do it, and not accept the work hoping to get some neighbor to do it for him and allow him a commission,

say the United Typothetæ and Franklin Clubs of America in three of their twenty-eight canons.

The American Bakers' Association members each make solemn pledge that:

I will use no materials or ingredients other than those of known purity and wholesomeness in the manufacture of my products; I will at all times adhere rigidly to the truth in all my advertising; I will keep my plant and premises at all times as clean and sanitary as is humanly possible, and welcome public inspection at all times. I shall expect of my employees what the public has a right to expect of me, that we keep ourselves morally and physically clean.

Two significant passages in the Credit Men's code read:

It is improper for a business man to participate with a lawyer in the doing of an act that would be improper and unprofessional for the lawyer to do. The pledged word upon which another relies is sacred among business gentlemen. The order for a bill of goods upon which the seller relies is the pledged word of a business man. . . .

And the contractors write as their preamble:

The Associated General Contractors of America realizing:

(1) That the construction industry vitally affects the well-being, comfort and safety of the public in its home life and daily vocations;

(2) That the responsibility of all individuals connected with the industry, therefore, assumes a professional character of honor and trust; and

(3) That these individuals desire to maintain the highest standard of professional conduct in their relations with each other and with the public—

adopts the following code of ethics, supplementing its motto, "Skill, Integrity and Responsibility."

It is not uncommon to hear folk who are still thinking in terms of physical compulsion sneer at such codes as unenforceable. As a matter of fact merely for business to take itself seriously already induces an elevation of standards. Codes of professional ethics are not enforced by sheriffs but by a consensus of social opinion based upon an acknowledgment of their reasonableness and built up by just such formulations and promulgations as that of the bakers and the printers.

A consensus, moreover, soon takes on some very practical forms. The Society of Civil Engineers, founded in 1852, and of Mechanical and Electrical Engineers, founded in the '80s, had a profound effect upon the ethics of their professions by forming codes and mak-

ing known the working standards of respected members. The belief that bad advertising will drive out good, as bad money drives out good, invited the advertising men to appoint a National Vigilance Committee, keen to find and expose lying advertisements. In fact, the first stage of organization among all the professions, Mr. Kohn writes in the May, 1922, *Annals of the Academy of Political and Social Science*, "was to protect the members against unfair competition, and to improve the profession in public consideration," their concern for public welfare finding expression at a later stage. In the same volume, which is chiefly devoted to studies of ethical codes, E. J. Mehren writes concerning the budding profession of journalism:

The medical profession enforces its codes through the county medical societies; the legal profession through the state bar associations. There is need in the journalistic world of an organization or organizations through which the social responsibility of journalists can find expression.

The more mature Association of Railway Auditors—sure footed in its ripe thirty-eighth year—revises annually, and upon steadily higher standards, its book on *Railway Accounting Procedure*, and makes mandatory each year an increasingly large section. In 1922, retiring President Ekin said:

The modern railway accountant has become a critic responsible for detecting unnecessary wastes in operation and for testing efficiency in current administration. He is responsible for pointing out those tendencies in the business world, the recognition of which is essential to the successful administration of a property.

Ostracism by business administrators, expulsion from their associations and then legal disbarment will all come in their time, inevitably and naturally. For it is as certain as future events

can be that the position of business manager, affecting the waking lives of thousands, will be given a legal standing involving intellectual qualification, character requirements, and social credit. The misery and misfortune an unqualified physician or lawyer can bring to a few hundred of his fellow beings is at most a small fraction of *what can be accomplished* by a factory manager, ill-equipped by nature, or training or both, to prescribe the lives of thousands of men and women. We have made believe that foremen and superintendents are fit if they have accumulated experience in their years of apprenticeship; but at the best it is the hope of immediate results which has too exclusively controlled their selection and promotion; their ability as leaders of men has been incidental or accidental. The business engineer has already begun to recognize that he must furnish qualified leaders for his men.

In the gradual giving way of artificial authority built upon force, the rise of an influence in industry akin to natural leadership becomes possible. To be permanent such influence must grow out of clear thinking, a study of actual facts, and motives higher than selfish

interest. And to wield such influence gives warrant to a pride which will not countenance practices of low ethical standard, nor find satisfaction in continual warfare.

The highest professional practice civilization yet knows has established itself thus through slow stages of studious research, increasingly rigorous training, a growing pride of occupation, a broadening motive, and, as a result, a social recognition which gave to professional standards the cogency of high law.

We are today laying the foundation of a new great profession which will devote itself to the service of man in producing and distributing material wealth. It will use most of the professions of present standing and many sciences and it will foster special researches into the domain of truth. It will make severe demands of its members since their opportunities for service and, hence, their responsibilities will be great. It will seek a balanced development in its ethics, science and education; and moved deeply by a sense of social responsibility accept humbly and without sentimentality the guidance of the spirit of service.

Book Department

SAMUEL GOMPERS. *Seventy Years of Life and Labor: An Autobiography*. Pp. 1184. Price, \$10.00. 2 Vols. New York: E. P. Dutton and Company.

Samuel Gompers was essentially a man of action. He did not pretend to be anything else. He never claimed to be an economist nor a philosopher and we find none of either in these two elaborate and on the whole most interesting volumes. True, there is a chapter which he calls "My Economic Philosophy," but it does not amount even to a confession of faith. It discloses his ardent hatred of what he considered injustice; his love of children and his desire to protect them; his love of his fellowmen or perhaps it would be more accurate to say his fellow-workers, for he literally had no time for Socialists or those who opposed his views. He was willing enough to leave them alone if they left him alone, but if they wanted a fight he was willing to give them what they wanted and in full measure. He loved a fight, he never shirked one and when he got into one he bore himself valiantly. Some of the best parts of his story deal with his numerous encounters with Socialists, politicians and representatives of manufacturers. He was more than a militant force in labor, however. That was only a phase of his life and activities. He was pre-eminently an organizer, and militancy was simply one of a quiverful of weapons. He organized his trade, then the American Federation of Labor and during the recent war, he organized labor generally.

In describing his "economic philosophy," which he does as one would expect a man of action to do it, he declares that he "intuitively rejects the theory of classical economists" because it was "revolting to me that human beings should be used without regard to their needs or their aspirations as individuals." In those two sentences he discloses two important phases of his character. He acted intuitively; he was an individualist.

These two volumes are loosely organized, but they abound in facts and incidents of several stormy periods of our national life. They have distinct human value and some

historical value, but their chief interest is not only the disclosure of a man, but the story of a life of great activity and usefulness, as it is now generally conceded that Gompers contributed largely to the betterment of labor conditions and to the sane and effective organization of workmen to improve their economic conditions.

He knew men, high and low, rich and poor. He liked them and they liked him, for there was no sham or pretense about him. The two volumes abound in reminiscences of the men he knew—one chapter being devoted to the Presidents he knew; another to the injunctions that he had encountered. His views on, or rather his activities in behalf of, sundry causes are given in an illuminating way, so that we get a clear conception of his policies, which are, as was to be expected, discussed at length although not always consecutively. He also tells why he abandoned pacifism. One of the most interesting sidelights is that which he throws on his love of music and the stage generally and his friendship for singers and actors. He devotes one whole chapter to the opera and drama, another to education and women's work, recounting with satisfaction how he helped to write in the Treaty of Versailles, "justice for women in industry."

One of the most pregnant sentences of his concluding chapter on "Problems after Armageddon" is this: "The government can supply counsel and information on industrial problems, but industries and all elements concerned must finally work out the solution."

CLINTON ROGERS WOODRUFF.

SALMON, LUCY MAYNARD. *The Newspaper and the Historian*. Pp. vii, 519. Price, \$7.50. New York: Oxford University Press, 1923.

SALMON, LUCY MAYNARD. *The Newspaper and Authority*. Pp. vi, 467. Price, \$7.50. New York: Oxford University Press, 1923.

Increasing recognition that the newspaper is an important element in the making of society has brought from the presses recently a host of books upon journalism.

Among these none is better deserving of commendation than are two volumes from the pen of Lucy Maynard Salmon, professor of History at Vassar College—*The Newspaper and the Historian* and *The Newspaper and Authority*.

These companion books are a thorough consideration of the newspaper as source material for the historian. *The Newspaper and the Historian*,

which is the first volume, considers the essential characteristics of the newspaper as they affect the historian and as they are made known by the newspaper itself, unaffected by official control.

The second treatise concerns itself with the press as historical source material in the light of the restrictions of external authority.

Few, if any, more authoritative works exist upon the subject of journalism. Miss Salmon has attacked her subject in a thoroughly scientific manner, an attitude deplorably lacking in so many critics, both derogatory and constructive, of the press. She has been willing to dig through masses of material to discover sources; she has covered every field, apparently, which gave promise of contributing anything of value; she has not been tempted to make statements without furnishing reasons therefor. Almost every page bristles with footnotes, which frequently consume more than half the space. The footnotes, in many respects, are the most valuable part of the works, forming as they do an introduction to a broad and somewhat unrecognized field of the literature upon the press. A great portion of the references are, appropriately, from newspapers.

For one who, presumably, has never been connected with the press, Miss Salmon shows a remarkable understanding of the technique of the newspaper and of its internal requirements. Newspapermen have been inclined—with justification—to take without great seriousness most discussions of the press by laymen, who, as a rule, have little comprehension of the requirements of newspaper publishing. This charge cannot be brought against Miss Salmon.

The Newspaper and the Historian covers the chief aspects of the newspaper: the development of the newspaper, its per-

sonality, the guarantees of the probability of its reports, its extra-technical activities, the methods of gathering and disseminating news, the editorial, criticism, illustrations, the advertisement, the authoritativeness of the newspaper, its authenticity and its value to the historian. Miss Salmon proves her ability as a writer of history by the chapter on the development of the newspaper, where, in a short space, she clearly and interestingly shows the origin and trend of the newspaper.

What the historian wishes for the newspaper is not news—that always ultimately comes to him from other sources—but a picture of contemporary life. . . . The parts of the press that are most obviously of immediate service in reconstructing the past are the editorial, the illustration and the advertisement,

Miss Salmon concludes.

The second volume, that concerned with the restrictions placed upon the press by external authority, is a more unified discussion than the companion work. It concerns the limitations over which the press itself has little or no control, and especially that exercised by government. Miss Salmon takes advantage of the great amount of material now available upon the control of the press during the World War, which, consequently, forms an important part of the book.

Thus by inherited and by acquired characteristics, authority and the press have been antagonistic, the conflict between the two has never been definitely settled, and in its very nature it seems incapable of settlement,

states Miss Salmon, although later in the volume she holds that the conflict can be settled when the press is willing to insist upon its freedom. There are many who will question her latter conclusion. They will reply that until newspaper readers are ready to insist upon a free press the newspaper will continue to be hampered by authority. Miss Salmon herself appears to recognize this in her first volume, for she declares

. . . that the press shares with every other known human activity, collective or individual, the restraints inherent in human society, and probably to no greater or less degree.

No little of the value in these volumes on the newspaper lies in their interesting presentation. The subject could be treated in a dull manner, but Miss Salmon has avoided this and has produced a work attractive as well as valuable to the newspaperman, to the teacher of the social sciences and to the layman who wants to understand his newspaper.

LESLIE HIGGINBOTHAM.

GEORGE S. DOUGHERTY. *The Criminal as a Human Being*. Pp. 290. Price, \$2.00. New York: D. Appleton & Company.

Mr. Dougherty would have been one of the first to broadly smile had a book which was radical enough to describe a criminal as a human being been published when he first began his brilliant career as a detective thirty years ago.

The literature of criminology was a rather sterile one in those days, especially as compared with the flood of volumes of the present time. What little was being written on the subject did not emanate from officers of the law who had yet to learn that their everyday experiences would furnish "best sellers" for the reading public.

If read only as a series of interesting anecdotes that are no less thrilling because they are from real life, this book is worth while. Mr. Dougherty is a good story teller and he also possesses a trait somewhat rare among detectives—a sense of humor.

But the book has a broader significance. The writer wins one's admiration by showing that the longer he pursued his task of running down criminals, the more mellow he became in his attitude toward them. There is no maudlin sentimentality about this doughty sleuth. But the reader is bound to believe the sincerity of his words when he says that "the greatest satisfaction I have had in my work is not that of successfully detecting crime and convicting criminals, but in helping them go straight after they had done their bit and paid their debt to society." More and more the men who are most vigorous in the detection and prosecution of lawbreakers are concerning themselves with preventive or reformatory agencies as well.

This detective's spirit is of a piece with that which some years ago animated four men in a large city to start the Boy Scout movement: a judge of the criminal court, a director of police, a trustee of a penitentiary and an assistant district attorney.

One should read Mr. Dougherty's book so as to come to believe that the intelligent successful detective of today is as human as the man he hunts.

SAMUEL P. ROTAN.

MORLEY, FELIX. *Unemployment Relief in Great Britain—A Study in State Socialism*. Pp. xviii, 203. Price, \$2.00. Boston and New York: Houghton Mifflin Company, 1924.

This Hart, Schaffner & Marx prize essay (awarded second prize in 1924) deals with the system of unemployment insurance and the operation of the labor exchanges in Great Britain. In its approach, views, findings of fact, and suggestions it is to be set over against Cohen's *Unemployment Insurance and Insurance by Industry, The Third Winter of Unemployment*, and most of the other writings on the subject. Its chief value lies in that fact.

Morley has come to his task with the conviction that the state is not fitted to operate social machinery as delicate and variable as unemployment insurance requires. He maintains that in Britain the system of unemployment insurance has failed of success, not only because of the post-war strain thrown upon it almost immediately after the extension made in 1920, but also because of inadequate contributions and other things which would have brought disaster in the long run and which should have been foreseen from the beginning. Nor is this all. He maintains also that the system has interfered with the proper functioning of the employment exchanges.

The thoughts and energy of those who should have had as their first duty improvement in the placing work of the Exchanges were absorbed in keeping up with the endless detail of a protean insurance program. The effect of these acts (1920 and later) in hampering the development of placing work can scarcely be exaggerated. Truly, it is not surprising that so few of the potential benefits of the Employment Exchanges

have been realized. On the contrary, it is little short of remarkable that in spite of the terrific burden of unemployment insurance they have held their own so well (pp. 145-6).

Though it will take time to make the shift and the shift will involve the solution of many problems, the way out of the undesirable situation is to be found in insurance by industry, the several funds or schemes co-operating with the national system of employment exchanges and also receiving subsidies from or paying revenues into a central government fund.

Because of space limitations the reviewer cannot list, much less discuss, the numerous questions raised by Mr. Morley's volume. The author's handling of much of his data is far from conclusive. All too frequently matters are disposed of in rather emphatic language with limited and inconclusive evidence. The sentences quoted above offer a good example. It is readily admitted that the British system of employment exchanges has its deficiencies. It is admitted also that most of the time of the staff has been consumed in administering benefits, keeping records, etc. But what ground is there in fact for the assertion that "so few of the potential benefits of the Employment Exchanges have been realized?" Language to pretty much the same effect is found at many points scattered throughout the volume, but nowhere does the author become specific and give the reader a bill of particulars or state in just what additional ways the exchanges could have functioned. The primary function of exchanges is to prevent leakage and to make proper placements; they can do little directly to increase the number of jobs. Have not most vacancies been filled rather promptly by the exchanges or otherwise, especially during the post-war period? One difficulty has been that many employers have not notified their vacancies to the exchanges. This can be cured only by compulsory notification, which may be desirable, but is not dependent upon the presence or absence of government-administered unemployment insurance.

The author is adversely critical of the many changes made in the insurance system in 1921 and later. Certainly the system of insurance was undermined, and this

will be vigorously criticised by all who have the professional insurance man's point of view. But did not the concrete situation call for what was done, though it was inadequate, rather than for full reliance upon ordinary poor relief? The reviewer would agree with the position taken by the authors of *The Third Winter of Unemployment* rather than with that taken by Mr. Morley.

The system of unemployment insurance was adopted in experimental form in Great Britain. Unemployment insurance is still in the experimental stage. Mr. Morley's book should be read by all who are interested in this important subject, not because it is conclusive, for it is not, but because it stands over against most of the discussions that have appeared in book form, and because it raises questions calling for further research.

H. A. MILLIS.

HULLINGER, EDWIN WARE. *The Reforging of Russia*. Pp. 402. Price, \$3.00. New York: E. P. Dutton and Company, 1925.

The book parallels *The First Time in History*, by Anna Louise Strong, which was published just a year ago, and though this comes out a year later it is perhaps not quite so up to date in its sources. Nevertheless it is a genuine contribution to the spread of long delayed understanding, because it is both readable and sympathetic.

There is occasional repetition and some inexactness. Speaking of Kerensky we find: "He even abolished capital punishment." It was in the army that he abolished it and thus is credited with having undermined discipline. It had been abolished in civil Russia long before the war.

The whole book is written from the point of view that "People are more important than governments," and so while there is a thrilling description of the ruthless secret service, yet, perhaps nowhere else is there a better portrayal of the really vital forces that inhere in the Russian people, which gives everyone who has ever been in Russia a faith in the future that is quite the opposite of that which can be derived from the popular myths.

The style of the newspaper man with his objectivity and energy results in a book

that can scarcely be called scientific, and makes the reader doubt sometimes the validity of some generalizations, but with regard to Russia everyone's generalizations are questioned.

HERBERT ADOLPHUS MILLER.

IBAÑEZ, VINCENTE BLASCO. *Alphonso XIII Unmasked*. Pp. 121. Price, \$1.00. New York: E. P. Dutton and Company.

In a clear, concise style and with tremendous dramatic effect, the author cries his message from the housetops that all may hear. What he terms his great love of country has prompted this bold denunciation of the present political régime, and whether the policy of complete exposé of a reigning power by a fellow countryman is wise or not and will gain any useful end, we will not discuss, but one cannot but admire the fearlessness and directness of attack. The historic background upon which the fabric of inherent weakness and political intrigue of the king is woven, is both clever and well portrayed. Some sidelights on the position of the country and its ruler during the Great War are also of interest.

One cannot help feeling, however, that the book, as a piece of literature, is a fire-brand which falling indiscriminately into ignorant, excitable hands as well as the *intelligentsia*, may do more harm than good.

E. A. O.

MILLER, HERBERT ADOLPHUS. *Races, Nations and Classes*. Pp. xvii + 196. Price, \$2.00. Philadelphia: J. B. Lippincott Company, 1924.

This book is most timely, for the interest in races, nations and classes was never greater perhaps than now, and the need for sound thinking along these lines is also paramount. The book is made up, not from other books, but from the author's personal contacts among immigrant groups in many European countries as well as in the United States. The discussion, thus, is replete with new and living reactions from a humanity which is restless and dissatisfied in its search for freedom, and which is more or less blindly seeking a new social and economic order. The author pleads for an understanding of what is "actually hap-

pening" in the "attitudes" of races, nations and classes. His aim is the worthy one of finding ways whereby "the legitimate results sought by revolution may be secured by peaceful processes." He also seeks the means whereby "psychopathic attitudes and destructive secondary organizations which always accompany revolution, and which complicate the social processes, may be escaped."

In analyzing the current reactions of many races, such as the Jew, the Irish, the Indian (East), the Korean, as well as of the proletarian classes, Professor Miller uses psychoanalytic and social psychological tools of the latest type, such as the following concepts: oppression psychoses, compensatory actions, and defense complexes. He makes extensive use of the concept of the "horizontal group," such as a caste; and the "vertical group," such as a race that claims itself to be "superior." The statement that "justice is psychological rather than moral" needs further development and clarification; justice is perhaps both. "Cultocracy" is used to refer to the attitude of those who have an individualistic idea of culture and hence justify themselves in "lording it" over "the less fortunate."

The concept of "proportional loyalty" illustrates how the author repeatedly cuts directly across traditional beliefs, and urges new approaches to the study and solution of the problems growing out of the conflict of races, nations and classes. Not a one hundred per cent patriotism within the respective nations of the world, according to the author, but a ten or twenty per cent national patriotism would be sufficient for national growth and necessary if there is to be world progress without war. Eighty to ninety per cent loyalty to common human interests is urged. The author's contention is that people are not naturally more than ten or twenty per cent different, but that an exaggerated nationalism has made them seem far more different than they are, even made them bitterly antagonistic. After all, in their basic desires, they are largely the same. To the reader whose mind is pretty well made up in its racial opinions, this book will be provocative if not definitely antagonizing; to the one with a wholly open mind, it will be stimulating and

enlightening, especially in the insight into human nature which it discloses.

E. S. BOGARDUS.

MERRIAM, CHARLES EDWARD, and GOSNELL, HAROLD FOOTE. *Non-Voting, Causes and Methods of Control*. Pp. xvi, 287. Paper \$1.60, cloth \$2.50. Chicago: The University of Chicago Press, 1924.

This is the first serious attempt to analyze a problem that is giving increasing concern to those who are interested in the success of democratic government. By means of a comprehensive and thoroughly organized field inquiry, the authors have evaluated the various causal factors that kept voters at home in a particular Chicago election. These causes are classified as physical, legal and administrative, disbelief in voting, and inertia, with a variety of sub-classes under each of these. The principle data, recorded by graduate students upon uniform schedules, was obtained by means of interviews with some 6,000 non-voters. In the tabulations a distinction is made between those who failed to register and those who, having registered, failed to vote; likewise between habitual and occasional non-voters. The tables are arranged further in such a way as to exhibit differentials in voting habits associated with sex, race, nationality, economic status, length of residence in the city, occupation and age. The data were checked in a variety of ways by supplementary inquiries. With the relative importance of various factors in non-voting clearly indicated, the possibilities of control become apparent. Several factors of somewhat minor importance, such as "congestion at the polls," offer little difficulty. "General indifference," the largest single type of causes, on the other hand, will be more difficult to overcome.

Exact scientific standards are reflected in the methodology employed. The sampling was particularly scrupulous. Unwarranted inferences are avoided, and the authors avow a hope that many similar studies elsewhere will enlarge and correct their own findings, which apply only to a particular municipal election. To this end "suggestions as to procedure in future studies" are offered. It is to be doubted whether the plan of assigning a single ma-

jor cause for each case of non-voting was a helpful or necessary step in analysis, especially since this assigned cause was dependent almost wholly upon the non-voter's own statements. Methods of inquiry concerning the analogous problem of criminal delinquency might have offered some precedent here. Thus Healy says "it is very rarely that any one factor in the background can be reasonably selected as the sole cause . . . the fact is that usually several causes are interwoven." Some attention is given by the present authors to the plurality of factors, and it must be acknowledged that on the basis of their data no change in conclusions would have been likely to follow another procedure.

Wider significance attaches to this volume because of the evidence that it offers of a reorientation now under way in political science. A "science of politics" is in process of formation, to no small degree as a result of the influence of the distinguished senior author of the present study. That the volume appears under the auspices of a joint organization for research formed by the social science departments of the university—"an expression of community of interests of the social sciences"—is a further significant detail of the same kind.

STUART A. RICE.

WILDE, NORMAN. *The Ethical Basis of the State*. Pp. 236. Price, \$2.50. Princeton University Press, 1924.

In the author's own words "this book is a study of some of the aspects of the problem of the state." He believes that "before we attempt to reform or abolish the state, we should have as clear an idea as possible of the nature of it and of the social purpose it has served." Further, "the justification for a popular treatment of these principles at this time is to be found in the fact that discussion of political theory is no longer confined to experts, but is a matter of universal interest."

The scope and purpose, as indicated in the above quotations, have been faithfully executed and, in the opinion of the reviewer, no better brief analysis of classical and recent theories has been published. There are two parts: first, historical, in which he traces the idea of the state through the

classical and recent theories; and second, problems of the state, in which the social will, rights and duties, nature and purpose of the state, sovereignty, justice, liberty and democracy, and the final loyalty, form the chapter headings. But the ideas in each of these chapters are, in the last analysis, simply different angles from which the author views and analyzes the fundamental theme of the book, namely, the relation of the individual to the community or state with the ultimate purpose of ascertaining the final loyalty that will result in the greatest good.

And since the basis of the state is ethical it naturally follows that the essence of freedom does not consist in the form of government but in the character of the popular will finding expression through it, and that political justice, to be realized in the state, must be through some form of organization fitted to express the wholeness of life, which is best evoked in the neighborhood group or the "ideal community." Since justice is not a mere abstraction but consists in being just to one's fellowmen, our final loyalty should be directed to this end. We can never reform American politics from above, by reform associations; change for the better must come from below, through local communities, which is simply another way of saying, what is perfectly sound, that morality is the cause, not the result, of political justice. As an introduction to political theory, this is a splendid book.

KARL F. GEISER.

PAGE, THOMAS WALKER. *Making the Tariff in the United States*. Pp. x, 281. Price, \$2.50. New York: McGraw-Hill Book Company, 1924.

This is the second book published in the Series of Investigations in International Commercial Policies by the Institute of Economics, the first being Wright's *Sugar in Relation to the Tariff*, reviewed in the January number of THE ANNALS. Mr. Page's active work with the Tariff Commission, for several years as member and for some time as chairman, together with his previous economic training and experience, fit him peculiarly to write this instructive and interesting work.

The purpose, as explicitly stated, is to

point out practicable means of reforming the procedure of tariff making rather than to discuss tariff policy, the latter being mentioned only when thought necessary to show the inadequacy of the usual method of legislating.

Mr. Page discusses in turn "tariff making without method," "tariff making by commission," "tariff making by executive order" and "tariff making by formula," pointing out the shortcomings of each. He deplores the small amount of influence which our Tariff Board and Commissions have had. He holds that tariff making by executive order or by an administrative body is unconstitutional unless it is narrowly restricted by Congress, in which case it becomes of little use. The so-called "flexible" provision of the present (1922) tariff law, which authorizes the President to lower or raise the rates named by Congress by not more than 50 per cent is not very workable, as it puts an impossible burden of many minor investigations upon the Tariff Commission and thus diverts its energies from major investigations. The author forecasts the repeal of this provision.

Mr. Page condemns especially the cost-of-production formula embodied in the present tariff law, says that it is based upon false premises, results in ever-increasing tariffs to foster inefficiency and, logically applied, leads to extreme absurdities.

After discussing the need of the Tariff Commission for more adequate means to secure better information regarding the effectiveness of foreign competition; the incidence and effects of duties; unfair trade practices; the relation of the tariff to natural resources, labor supply, and public welfare, the author then comes to his "practical agency of reform."

The fundamental problem of reform according to Mr. Page, is informing Congress and the public so clearly that all may know what will be the effects of any proposed rate or rates. Then Congress cannot act in ignorance and public opinion will condemn the maneuvers of special interests seeking advantages contrary to the public welfare. He believes it is insufficient for the Tariff Commission to furnish Congress and the President the facts without comments and suggestions as to the effects of specific rates.

Under the plan which the Tariff Commission has been required to follow in the past, neither legislators, nor the general public which ultimately determines their policy, have been sufficiently well informed to bring about fair and wise tariff legislation. Mr. Page would have the facts presented, interpreted, explained and published in such ways that all may understand the effects of various possible schedules as promptly as the Tariff Commission can make such information available. He would not have the Commission undertake to determine policy, to "take the tariff out of politics" for he maintains—and properly—that this cannot be done, but he would have the Commission name the rates which would "maintain equality of opportunity for foreign and domestic industries." In other words, apparently he would have it name rates that would maintain the *status quo* of existing industries. Taking a schedule of such rates determined by the Commission as a basing line, Congress could then depart from it in either direction and to such extent as it saw fit to carry out policies determined by it, whether of more or less protection or of more or less revenue.

This study is somewhat unique in that it contains a criticism in an appendix by Mr. E. G. Nourse, another member of the Council of the Institute of Economics. He claims that Mr. Page's proposed remedy, especially the naming of rates that would maintain "equality of opportunity," rests upon impracticable assumptions, that the author's argument is "merely an elaboration of the comparative-cost fallacy" which he himself had ably condemned. Rather than have the Commission follow this indirect, "deceptive and even more difficult, not to say impossible [method], of valid determination" it would be better to have it attempt to answer directly the question: "What is the effect upon American production and prices of the existing tariff rate, and the corollary question, what would be the probable effect of some other (specifically proposed) rate?"

Mr. Page's book is very valuable for the light it throws upon the weak points in the usual procedure of making tariff schedules. Perhaps its greatest value consists in the illustrations drawn from the wealth of the

author's experience which show among other things the falsity of many common generalizations and the necessity of discrimination and much experience if tariff discussions and tariff making are to avoid the usual errors of the past. The criticism by Mr. Nourse appears well taken and there are numerous minor points which the reviewer would call in question in a detailed review but, on the whole, he considers this study illuminating, suggestive and well worth while, a contribution calculated to help in the slow process of education upon which the author concedes and argues that reform must be based.

ROY G. BLAKEY.

KELLOR, FRANCES, and HATVANY, ANTONIA (collaborator). *Security Against War*. Vol. I. *International Controversies*; Vol. II. *Arbitration, Disarmament, Outlawry of War*. Pp. viii, 850. Price, \$6.00. New York: The Macmillan Company, 1924.

This is a comprehensive and, on the whole, a meritorious study of the means already in existence or proposed, for the establishment of national security, reduction of armaments and the prevention of wars. The first volume contains an exposition of and a commentary on the Covenant of the League of Nations followed by a survey, analytical and historical, of its varied services, such as the administration of the Saar basin, and its activities in the settlement of international disputes. The second volume deals with the Hague Court of Arbitration, the Permanent Court of International Justice, including an analysis of the advisory opinions and judgments of the latter court, the problem of security and disarmament and the outlawry of war. Proposals such as the treaty of mutual assistance, the American draft treaty, and the Borah and Levinson schemes for the outlawry of war are analyzed and criticized. Unfortunately, the book was published before the elaboration of the Geneva Protocol for the Pacific Settlement of Disputes, and in consequence that proposal is not considered.

Students will find a large amount of well-digested and logically arranged information concerning the subjects treated. Many

will no doubt regret that the attitude of the author toward the League, its various organs and agencies and even toward the Permanent Court is on the whole unsympathetic. Those who believe the League has fully justified its existence will not find much in the author's appraisal of its achievements to justify their confidence. According to the author, its failures have distinctly outnumbered its successes. The Council of the League, especially, comes in for much criticism and even the decisions of the Permanent Court in some cases are unfavorably judged. On the whole, the author's survey of what has been achieved in the interest of international peace and justice by the League and the other institutions which have grown out of it, since the war, is not encouraging. Aside from what to some will seem evidence of bias, justifiable or otherwise, the work possesses distinct merit and will prove of great value to students and to the general public.

J. W. GARNER.

CARVER, THOMAS NIXON. *The Economy of Human Energy*. Pp. xiii, 287. Price, \$2.50. New York: The Macmillan Company, 1924.

"The only serious form of waste," says Professor Carver, "is the waste of man power or human energy." Being prosperous, in other words, is essentially a matter of getting the best possible return for our expenditure of energy. How to do this is the theme of Professor Carver's book.

Professor Carver finds it easier than many of us to arrive at general conclusions and he is not afraid to express himself unequivocally and even dogmatically. Hence the book bristles with thought-provoking assertions. Chronic unemployment in Great Britain, for example, is explained by the entrance of too many talented men into the genteel professions, leaving a shortage of capable business managers, and by the unemployment dole which, by compelling managers to pay unproductive laborers as well as productive ones, reduces the enterprises that are able to survive. Whether one agrees with it or not this explanation furnishes much food for thought. More clearly in need of qualification is the assertion that the best way to give to the poor is

to invest in profitable enterprises. Do funds spent for parks, playgrounds, or scholarships yield real income any less than money invested in shoe-making machinery—or perhaps in a Peruna factory?

The omissions are important. It is strange to find in a treatise on the conservation of energy almost no discussion of the unemployment problem in the United States or of the circumstances which prevent workmen from being interested in output and costs and induce them to restrict production. The direction of human energy by investors is stressed but almost nothing is said about its direction by consumers. How much waste results from the fact that consumers do not know their needs or the quality of goods, and to what extent do business enterprises enhance this waste by skillfully misleading consumers and by encouraging competitive consumption! Great inequality in the distribution of wealth does not impress Professor Carver as a source of serious waste and he sees little possibility that, by distributing more goods in accordance with needs, our expenditure of energy might be made to yield substantially greater returns. But although the analysis is at times faulty and although the book has some serious omissions, it is stimulating and more than ordinarily worth reading.

SUMNER H. SLICHTER.

KENT, FREDERICK C. *Elements of Statistics*. Pp. xi, 178. Price, \$2.00. New York: McGraw-Hill Book Company, 1924.

The assumption of Professor Kent, in his preface, that courses in mathematics are usually prerequisites for college work in statistics was truer five years ago than today. There undoubtedly is, however, a demand for books on statistics which do not require previous training in mathematics. The demand has principally manifested itself in a desire for books with a specialized viewpoint, for example, books which deal primarily with social, vital or business statistics. Statistical methods in connection with business data, as an illustration, have been tremendously amplified and refined within the past few years, and a book which is serviceable for social or vital statistics

proves inadequate for students of economic and business statistics. This is merely an example of the tendency toward specialization.

In some respects this volume is an anomaly. The early chapters refer to business uses of statistics and cite business examples. Little mention is made of social and vital statistics. In later chapters, however, the allotment of space and the methods described place no emphasis upon methods adapted to handling economic and business data. Thus index numbers receive less space than the normal frequency curve and trends, cycles and seasons are mentioned only once. Problems are supplied with each chapter but references are noticeably lacking. The problems are mainly problems of calculation rather than interpretation.

Much of this is perhaps justifiable if we regard the book as intended for an illustration of applied mathematics utilized in the solution of practical problems. The author probably projected it as a supplement to mathematics training and as a brief introduction to the field of statistical theory; for these purposes it is very satisfactory. It is intended for a one-semester college course and this is all it will serve for, without supplement. In the space available (178 pages) the author shows considerable ability in summarization and overcomes the space handicap as well as possible. Its simplicity and clarity can be highly recommended.

ROBERT RIEGEL.

BUTTERBAUGH, WAYNE E. *Principles of Importing*. Pp. xxi + 344. Price, \$5.00. New York: D. Appleton and Company, 1924.

This book could have been well entitled "Details Involved in Importing Goods into the United States." It does not meet the requirements of its present title if we understand a principle to be a fundamental truth or, as Mill describes it, a generalization from observed facts. In view of the liberties which have been taken with this term in recent years, we should not be overly exacting, but it does seem that we have a right to expect under the head of principles a discussion of subjects of a general and fundamental nature. For example, under

the title given one would perhaps expect a discussion of the following other subjects of general concern: the different principles of valuation of imported goods and the effect of these upon the flow of commerce; the principles governing ocean freight rates; the functions of entrepot markets; the functions of auctions and other organized markets as sources of imported goods; the use of auctions as methods of marketing goods imported into the United States; the principles of marine insurance such as the principles of general average and particular average. Most of these subjects are not mentioned and the others are disposed of with mere passing reference.

The choice of topics for discussion can be illustrated by the chapter on shipping and transportation. The 26 pages devoted to this subject are allotted to: choice of the container and packing (11 pages), marking the packages (6 pages), weighing and measuring the packages (3 pages), and miscellaneous topics (5 pages). Similar details are discussed in the fourteen chapters which make up the book.

A young man who, in the immediate future, expected to obtain employment in an importing house or who is now holding such a position, would no doubt find that from such a book he could obtain information which his "uneducated" competitors had been forced to pick up through contact with the business. The writer has no desire to imply that the imparting of such information as is here given is devoid of value, but still he is not very seriously alarmed by the fact that few collegiate schools of business administration devote courses to this phase of the subject. There are a sufficient number of subjects in which the institutions of higher learning have a peculiar advantage over the school of experience to make it appear a doubtful economy of time to consume any part of those valuable four years in instructing students in the advantage of a wooden box over a cardboard carton and other such practical bits of information.

The author has performed a service in putting into convenient form a mass of detailed information gained by his experience in import work, and the book should find a useful place as a reference source for matters of import technique. C. E. GRIFFIN.

BYE, RAYMOND T. *Principles of Economics*. Pp. viii, 508. Price, \$3.00. New York: Alfred A. Knopf, 1924.

There is much more to commend than condemn in this book, and the adverse criticism arises partly from the necessary limitations on the kind of book this is meant to be, and from legitimate differences of opinion as to the nature of such a book. It is a textbook, written with the aim of "making economics more teachable." It does this in plain and understandable language.

As an instantaneous acid test, the reviewer turned at once to the subject of value. The book stands the test well in this respect. It is almost incredible that many recent textbooks on economics should have been written in ignorance of or contempt for a logical concept of supply and demand.

The author would classify himself somewhere between the orthodox and the revolutionary economist. To the latter, he makes concession in form and in the order of treatment, but the essence of his treatment and the conclusions conform substantially to recent orthodox masters. Land, for

example, is called natural capital; return on artificial capital is called either interest or rent, conforming to popular usage; and income from land is called rent or interest. But the analysis, with the changes in names, and such confusion as this brings, is still orthodox.

The treatment of distribution is somewhat uneven. For example, the subject of wages is underemphasized, compared with interest and rent. One could wish also that the effects of certain institutional practices could have been more fully presented. For example, what is the effect upon the productivity of workers of the forms of the wage payment, as illustrated recently by the "gyppo" system on the Pacific coast? Yet, even here, the book leaves less to be wished for than most of its predecessors.

These, however, are minor complaints, on which not all critics would agree. Compliments are due the author generally for clearness and simplicity of presentation, and for aptness of the illustrations used. The book should find more than local use in college classes.

JENS P. JENSEN.

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FOUR YEARS OF LABOR MOBILITY

A STUDY OF LABOR TURNOVER IN A GROUP OF SELECTED PLANTS IN PHILADELPHIA

1921-1924

BY

THE INDUSTRIAL RESEARCH DEPARTMENT
WHARTON SCHOOL OF FINANCE AND COMMERCE
UNIVERSITY OF PENNSYLVANIA

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PREFACE

THE Department of Industrial Research of the Wharton School of the University of Pennsylvania exists by the aid of the Carnegie Corporation and a number of interested individuals and firms. With the co-operation of a group of Philadelphia employers and other members of the industrial community, the Department seeks to give practical response to the need for local units for co-ordinating industrial research in the more important centers of population.

As such a unit it makes continuous studies which pertain to problems in one industrial market. These studies should in time contribute information of value to students of general economic and industrial problems. They may have value to the immediate community and to teachers of industrial subjects by supplying facts on which constructive programs may be based as well as by indicating community conditions and tendencies.

This account is submitted as a more extended statement of scope and purpose and as a discussion of one of the studies, continued over a period of four years.

This study has been made under the immediate direction of Miss Anne Bezanson, who takes responsibility for the interpretation and writing of the report. The computation of data and the preparation of tables are the work of Miss Leda White and Miss Miriam Hussey. The chapter on occupations was made possible by two years work of Miss White on occupational classifications. Miss Hussey prepared the summary tables and assisted in all stages of the report.

JOSEPH H. WILLITS.

FOREWORD

IN publishing this study no claim is made for original methods or conclusions. For a decade industrial managers have recognized the place of the analysis of labor turnover in their own plants; this study aims to show the still larger place for this control in a community labor market. Inquiries from educators, industrial students, employment executives and research associations influenced the Department in bringing up to date the material published in a preliminary report on this subject in *The Annals* of September, 1922.

The Department is indebted to all members of the research staff, especially to Margaret Hile, Marian Herndon and Elizabeth Lockwood; and to Marjorie Crossingham for drafting and preparing charts.

ANNE BEZANSON.
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INTRODUCTION

IN September, 1922, the Department of Industrial Research published in *The Annals* of the American Academy of Political and Social Science a preliminary report entitled, "A Study in Labor Mobility," showing the effect of labor turnover in a small group of Philadelphia concerns. The present study was undertaken to bring up to date the data and findings of the earlier report. Compilation of data for this study has been in progress for four years. The contact with firms has been continuous. Standard methods of reporting have been followed. On the other hand, the whole study is based on a local situation and conclusions may or may not be valid for industry in general. The methods of collection and tabulation will be found in Chapter XI and Appendix A.

LABOR TURNOVER AND THE BUSINESS CYCLE

In a four-year analysis some of the larger currents affecting turnover in plants have become evident. In the turnover of metal plants, a consistency quite unexpected has been found in the rhythmic upward and downward swings. Individual metal plants have not maintained the same level of turnover. Among the different plants there is found every gradation from a very low average to a very high one. However, overshadowing these differences in general level is a tendency to parallel movement. The total turnover for the eight metal plants, with one exception, where radical changes were effected in production methods, started to rise in the early months of 1922 and continued a steady upward climb until the middle of 1923, when the curves for all firms moved downward. Objection might be made that

this similarity could be due to the inclusion of lay offs in the total turnover figure. However, when the lay offs and even discharges are omitted, the same tendency characterized the remaining curves made up of resignations alone. If a twelve months moving average be plotted for turnover rates of individual firms, each curve shows a pronounced upward movement in 1922 and the early part of 1923, with a marked downward trend throughout the last part of 1923 and the early part of 1924. By the end of 1924 turnover at all plants was not only low, but had reached a figure low beyond all precedent in the last decade. From the point of view of labor turnover then, the four years divide naturally into three periods. Despite heavy lay offs in 1921, turnover decreased markedly from month to month and continued low in the early months of 1922. The second period begins with improved business conditions about April, 1922, and lasts throughout the first half of 1923. At the same time demand for labor was active in the building industries. Growing out of the demand for labor in building, in addition to increased activity in industrial plants, turnover began to increase month by month throughout the last half of 1922 and 1923. This second period, then, is characterized not only by the hiring of new employes and by a high rate of labor changes, but by a rate rising continuously month by month until the middle of 1923.

The third period begins with an abrupt drop in turnover with the slowing down in production in the last half of 1923—a period of low turnover which ends only with the end of 1924. In essence, then, turnover rates moved upward and downward with the curve

of business activity. To be sure, these data are meagre on which to base such a general conclusion. However, whether or not the conclusion has wide application, the curves have all the characteristics of long continuance of the dominance of market factors. What significance attaches to such a conclusion? If factors within the trade and market determine the contour of the turnover curves, there is left only part of the turnover within the *immediate* control of individual firms. The difference in turnover levels in plants in the same industry, and dependent upon the same labor supply, is due doubtless to differences in internal conditions of the plant or differences in readiness to adjust wage rates. The upward swings of turnover in periods of business activity can be controlled only in so far as it is possible to control the business cycle. The inquiry as to what is a normal turnover is in somewhat the same category as the inquiry, "What is normal business activity?"

It is not claimed that previous investigators have failed to indicate a relationship between industrial depression and labor stability. The fact has been referred to, in passing, by most students of the problem. It has never been given special or extended study. The relationship has been ignored by executives in judging the effectiveness of devices introduced to reduce labor turnover. This or that device after a short period of trial has been claimed to have assisted in reducing labor turnover. It may have. If the cyclical character of labor turnover noted in this period proves to be a usual phenomena, the time that a device is introduced must be considered in judging of its efficacy. Any device introduced in the middle of 1923 would have made a favorable showing. The same device introduced in the middle

of 1922 might have kept rates at more moderate figures, but could scarcely have prevented some general increase. Any estimate of such devices must be made over an extended period. The conclusion, then, has both practical and statistical significance.

BROADER ASPECTS OF LABOR TURNOVER

Labor turnover is commonly discussed in terms of the movement of workers from one plant to another. This is the necessary emphasis of the individual plant; in separations in terms of morale and adjustments within the working force, and in replacements in terms of delays in production and increased costs. With this aspect of the problem, analyses of the volume of separations and new hirings at each plant are mainly concerned and to this phase of labor changes the term "labor turnover" may well be restricted.

The problem may be considered from a much broader point of view. It may be regarded as part of the whole phenomena of adjusting the supply of labor to the demand for it. For study of this aspect, comprehensive data over a long period are essential.

The analysis in this study gives a hint of the value of more inclusive material. It covers a period of rapid changes in the demand for labor, when market adjustments were unusually severe. The number on the payroll used to show the changes in demand for labor, minimizes the extent of the fluctuations. Payrolls do not decrease as much in periods of depression as does the actual volume of employment, owing to the working of short shifts and to the decreased number of shifts per week. In periods of increasing activity, payrolls increase less than the actual volume of employment. Even with this qualification, the drops

of 1921 and the last half of 1923 were marked and rapid; the increases of 1922 steady and continuous until the middle of 1923.

In general outline, curves of separation rates tend to conform to curves of employment. The activity of 1922 was accompanied by a marked increase in turnover rates. Curves mounted from month to month as recovery progressed and reached high points by the spring of 1923. Without any tendency to increase, high figures maintained in the three following months, shifting downward only with the shift in production activity of the last half of the year. A complete contrast to this rising movement was evidenced by the low and declining rates of 1924.

In general, curves for turnover rates and resignation rates conform closely. When causes for leaving were studied, items determining the resignations most affected by the fluctuation were found to be wages, working conditions and work elsewhere. The twelve months moving average of these causes increased rapidly in 1922 and 1923.

The high turnover for work elsewhere items is doubtless the exaggerated rates of the first period following a depression. Not only do wage rates lag behind in this recovery, but there is a long period of wide variation in amounts paid at different plants. Increases at some take place at once. From time to time increases follow at other plants, but for a long stretch of time there is great diversity in the rates paid at different plants in similar occupations. It is this variation in rates, not the lag behind prices and business activity, that gives impetus to the change of workers from plant to plant.¹ Interplant shifting not only

lets workers take some advantage of the increasing wage tendency, but forces more quickly upon management the necessity for adjustment in rates. Our data do not extend over a prolonged period of business activity when rates in the same occupation would tend to vary within narrower limits.

The movements of labor that adjust the supply to the demand are not confined to these interplant movements to which the term "labor turnover" is restricted. In somewhat exceptional circumstances movements of skilled workers take place from one trade to another. More frequently the movement is within the trade from work demanding one degree of skill to other work of a more precise or exacting nature. Movement may, also, be taking place from one grade of work to another, or from one locality to another. The readiness of adjustment between trades, between grades of skill and between localities is the movement to which the economist has applied the term *mobility of labor*. The rate of

67, and the average rate about 51. *Turret lathe* operators at the same time ranged from 37 to 83 when the modal rate was 55 and the average, 53. Doubtless there were differences in the content of work represented by these rates, but no such range would exist once conditions were more nearly equalized. The wide range results from differences in time of increases and decreases. An illustration may be given from the mining industry. In 27 mines in non-union areas of eastern Kentucky in the last half of 1920, wage rates per hour for *inside laborers* ranged from 65 to 85 cents with only four mines below 71 cents. Decreases occurred in the first half of 1921, making the range 37 cents to 81 cents. Further decreases in the second half of 1922 left a range from 34 to 70 cents at the same mines cited above. Reductions in the last half of 1922 reduced the range from 34 cents to 65 cents. In the last half of 1922 increases occurred, but unequally affected different mines, making a range from 55 to 81 cents. The existence of such a range can influence turnover in the first period of adjustment.

¹ In November, 1922, rates paid to *bench hands* varied from 24 cents per hour to 90 cents per hour in a large number of metal working establishments, though the modal rates were at

these adjustments may be greatly influenced by modern organization. Marshall says:

That general ability which is easily transferable from one trade to another, is every year rising in importance relatively to that manual skill and technical knowledge which are specialized to one branch of industry. And thus economic progress brings with it on the one hand a constantly increasing changefulness in the methods of industry, and therefore a constantly increasing difficulty in predicting the demand for labor of any kind a generation ahead; but on the other hand it brings also an increasing power of remedying such errors of adjustment as have been made.²

In so far as this is true, the present era may be subject to more than ordinary adjustment. Some of the movement may be taking place within plants or between plants, but at very different rates for occupational groups.

TURNOVER BY OCCUPATION

One of the newest phases of this report will be found in the chapter on turnover by occupation. We have attempted to consider differences in rates of turnover for skilled, specialized and unskilled occupations. Interest in this comparison does not center primarily upon the rate of turnover among skilled and unskilled workers. Agreement is fairly general that unskilled groups have highest separation rates. The zone of doubt is in the relation of turnover among skilled trades common to many types of industry and semi-skilled and skilled occupations peculiar to one type or branch of industry. Here great variation was found in the degree of stability at different plants. In a few cases semi-skilled workers and even unskilled, in one case, had lower turnover than skilled at the same plant; in others

turnover varied with skill. In three plants, the experience of one year in regard to turnover by grade of skill conflicts with the ranking of the groups in the following year. While in many cases turnover varied directly with skill, opposite tendencies show the complexity of factors determining change. It is unlikely that all occupations within any one group, as here classified, would be subject to the same demand factors. Analysis of the trend of turnover by occupational groups might show that turnover rates correlate more with shortage or surplus in the occupation than with degree of skill. In so far as turnover rates measure the market adjustment, they should tend to be high in those trades in which technical changes are rapid, or in which training is inadequately recruiting the numbers entering the occupation. One skilled trade may have a high turnover while another equally skilled has a low rate. Until market and plant influences are isolated, no conclusions based on the relation of turnover to skill can be drawn. The comments of skilled workmen quoted in the chapter on occupations offer the best explanation available to us for changes from shop to shop.

Both plant conditions and market factors influence labor changes. Some plants had a tendency to show higher rates than others at all times. This difference may be laid to working conditions, training methods and other intra-plant arrangements. These differences in the general level of turnover of similar plants, depending upon the same sources of labor supply, may be said to be within the immediate control of the plants. Nor do these differences represent the full extent of the possibility of reduction. The study of length of service shows that a considerable proportion of turnover occurs in the first weeks of employment. Meth-

² Marshall, Alfred. *Principles of Economics*, 1920, p. 573.

ods of placement and supervision of work can do much to reduce the high rate of shifting in the first weeks of the employe in a new plant, and in this respect the general level of even the lowest plant may be reduced. Among long service employes, turnover rates

were low, whether artisans, skilled or unskilled groups were considered. In so far as market factors control labor turnover, it can be minimized only by better utilization of labor or more ready adjustment to changes in rates taking place in the area.



CHAPTER I

VARIATIONS IN NUMBER EMPLOYED

FROM the point of view of labor turnover the four years covered by data in this study have been divided into three periods:

1. From January, 1921, to February or March, 1922.
2. March, 1922, to June, 1923.
3. July, 1923, to the end of 1924.

In this division, an important distinction that separated the first half of 1921 from the second half is disregarded—a distinction of a considerable importance when the industries are separately considered. The first five months of 1921 were characterized by an extremely rapid and steady decline in numbers employed. In the second half, improvement took place in many industries, while in others the general level of employment in the last half of the year was downward but at a perceptibly slower rate than in the first months. Both the severe depression of 1921 and the milder, but long-continued inactivity beginning in 1923, affected the reporting firms in somewhat different ways.

In fact, the years following the war and the activity of 1919 and 1920 left many unsettled forces at work in the industrial situation. Since labor turnover reflects this lack of equilibrium along with personal and community conditions, some review of the production conditions is essential for an interpretation of these data. The irregular operation of 1921 determines many items in this study. It is less easy to determine how long the unsettling effects carry over to a period of prosperous operation. Probably years elapse before workmen, forced to take any job that offers, finally drift back to the occupations for which experience and training fit them.

Certain general deductions may be made concerning manufacturing conditions by considering the number of employes on the payroll. By combining the monthly figures of firms working from the same basic raw material some outstanding differences are evident.

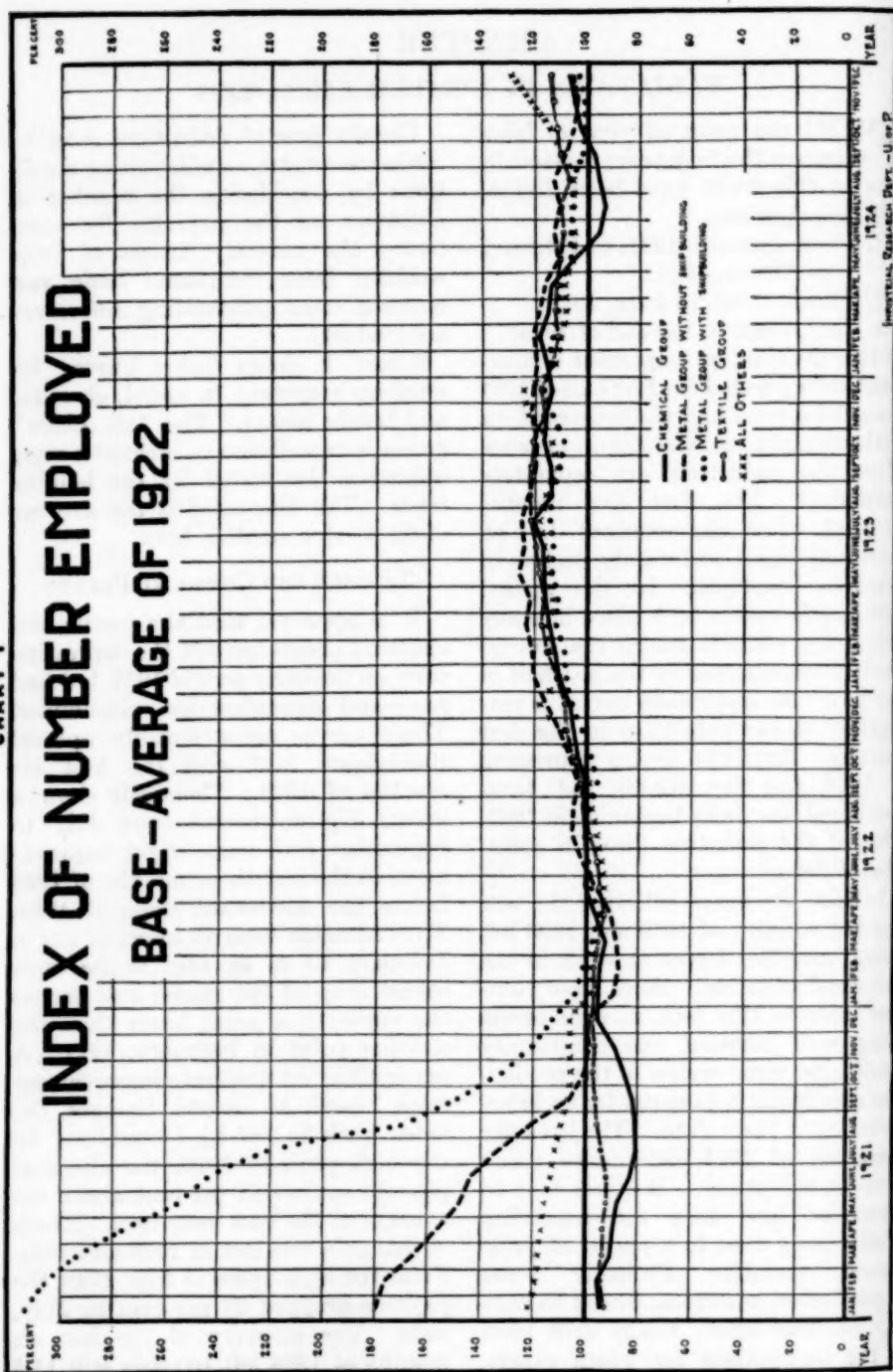
Chart I shows index curves for numbers employed in metal, chemical and textile plants. The "all others" group is miscellaneous, including some industries dominated by the holiday trade. The base used is the average of the twelve months, 1922.

TEXTILE AND CHEMICAL PLANTS

It is apparent that the textile and chemical plants had felt the depression through the early part of 1921, but had recovered somewhat by midsummer. These curves move steadily upward throughout 1922 and the first six months of 1923. Chemicals show a severe dip downward from July to September with some slight improvement in the last three months of 1923 before the downward slope of 1924. The reduction from an index of 118 in February to 93 in July is the most severe drop of the period and carries the curve to a point lower than the starting point in February, 1921. A perceptible but moderate improvement from month to month brought the index back to 107 by December. In the high peak of 1923, the chemical payrolls ranked 21 per cent above the average of the base year 1922. Much of this gain was lost in 1923 and 1924. From the high figure of July, 1923, the payrolls dropped 23 per cent by July, 1924. The recovery of the last six months of 1924 left payrolls still 11.5 per cent below the high point of 1923.

CHART I

INDEX OF NUMBER EMPLOYED BASE-AVERAGE OF 1922



Textiles fluctuated less severely than chemicals in 1924. The lowest point, in August, 1924, was 13.0 per cent below the high peak of August, 1923, with the end of the year 19 per cent above the lowest point in 1921, but still 7 per cent below the high point reached in August, 1923.

METALS OMITTING SHIPBUILDING

Owing to extreme adjustment in shipbuilding, the metals' group has been plotted with and without the weighting of shipbuilding payrolls. Whichever curve is considered, metals had, by all odds, the most severe decline in 1921—a decline that lasted until March or April, 1922. Strikingly heavy monthly losses are shown in the steepness of the metals' curve in all months preceding October. From then the decline continues though at a diminishing rate. In this period the decreases in metal payrolls are not only more severe than in textiles and chemicals but recovery is much longer delayed. Differences here might be occasioned by the time the various types of industries first felt the depression. The earliest to liquidate would be early in recovery and the net losses of these would be understated by curves beginning, as these do, in the middle of the depression.

The gains of 1922 are very gradual before September. Afterwards, significant gains took place from month to month until past midsummer, 1923. In this period the metal curve climbs above all other curves reaching its highest point in May, but experiencing no severe losses before the autumn of 1923. The past year began with a moderate but perceptible monthly decrease. In one respect, decreases in metal firms during 1924 were not so serious as those in chemicals since the metals' curve never reached so low a point; in other respects, the situation

was worse, owing to the extended period of decline and the lack of any evidence of gain even up to the end of the year. The losses of this year nearly balanced the accessions made in 1923, and brought the index figure of December within 6 per cent of the average for the base year, 1922. This means that the total decrease in payrolls was 22 per cent below the high point in 1923.

METALS INCLUDING SHIPBUILDING

To have included shipbuilding in the comparison of metals would have been to reduce the metal curve below textiles and chemicals without greatly changing the months in which a shift in direction occurs, or the general character of upward or downward movement. The year 1921 would have been extremely weighted by reason of war readjustment in shipyards.

Index numbers upon which this chart is based are given in Table 1.¹

INDIVIDUAL METAL FIRMS

Since metal plants are referred to frequently in later analysis, three of the individual firms making up the metals' curve are shown on Chart II (p. 11). The time of changes and the direction of movement of the curves are strikingly similar. Firm 10 fluctuated less violently but followed closely the contour of the curve for Firm 14. Recovery was more rapid for Firm 9, but the gains were partially lost in the summer of 1922. In the inactivity of 1923, Firm 9 dropped to a point lower relatively than either of the other firms. The extremes in this firm can be explained by its dependence upon the automobile trade for which it furnishes accessories.

¹ Throughout the study, it has been necessary to depart from the accepted statistical practice of printing absolute numbers as well as percentages. The detailed and local character of our data make it impossible to publish absolute numbers without identifying plants.

TABLE 1—INDEX NUMBERS OF AVERAGE NUMBER EMPLOYED
Base—Average 1922

MONTH	CHEMICAL				TEXTILE				METAL *				METAL †				ALL OTHERS			
	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924
January.....	94.4	95.4	110.6	115.2	92.7	96.7	111.7	114.4	179.1	89.4	120.0	119.8	313.1	103.5	107.6	114.9	126.1	98.8	110.9	112.4
February.....	95.2	95.0	112.4	118.1	94.1	96.7	115.8	111.1	176.3	87.6	121.7	120.9	306.2	101.4	108.9	113.4	119.8	97.8	114.9	110.4
March.....	90.1	92.8	114.2	115.0	93.2	95.4	117.5	112.5	165.1	88.8	123.8	118.7	294.5	97.7	112.3	111.4	118.5	96.4	115.5	108.8
April.....	89.9	96.6	116.0	113.8	93.2	93.4	116.8	112.3	156.6	90.8	122.2	116.9	276.6	96.4	111.9	110.7	117.2	94.3	113.2	108.9
May.....	87.7	100.7	116.8	105.7	92.2	95.1	117.9	111.4	147.8	96.7	126.0	111.7	256.4	98.3	113.9	106.2	115.7	93.5	114.0	106.6
June.....	82.6	100.5	117.0	95.7	92.2	96.9	119.0	109.1	143.0	101.4	124.6	112.5	244.1	99.7	112.9	106.5	113.1	94.5	117.3	105.3
July.....	80.2	100.8	121.2	93.3	94.1	99.5	121.0	110.0	139.0	105.4	125.4	111.1	221.1	100.7	114.4	105.5	111.0	96.2	117.6	105.4
August.....	80.8	101.8	113.2	95.5	95.3	101.4	121.6	105.7	121.3	105.3	122.6	112.8	170.6	99.3	113.3	106.0	109.4	98.4	115.2	105.4
September.....	81.2	100.4	113.4	97.4	95.9	102.7	121.5	110.1	105.4	103.3	120.0	108.0	148.3	96.6	110.7	102.1	107.3	99.4	111.1	109.7
October.....	85.1	103.5	116.9	102.7	96.5	105.9	120.1	111.1	100.4	106.0	119.1	105.1	132.3	98.1	109.5	101.2	106.8	103.3	113.4	113.8
November.....	89.4	105.5	116.1	105.0	96.1	108.0	116.6	112.6	98.9	110.1	121.9	104.4	120.2	102.2	113.8	101.5	107.3	109.8	122.5	123.6
December.....	95.5	106.8	113.1	107.3	96.8	108.4	117.1	113.2	99.3	115.3	120.9	106.3	112.8	106.2	117.0	103.7	107.1	117.7	124.0	129.4

* Metal Firms, not including shipbuilding.

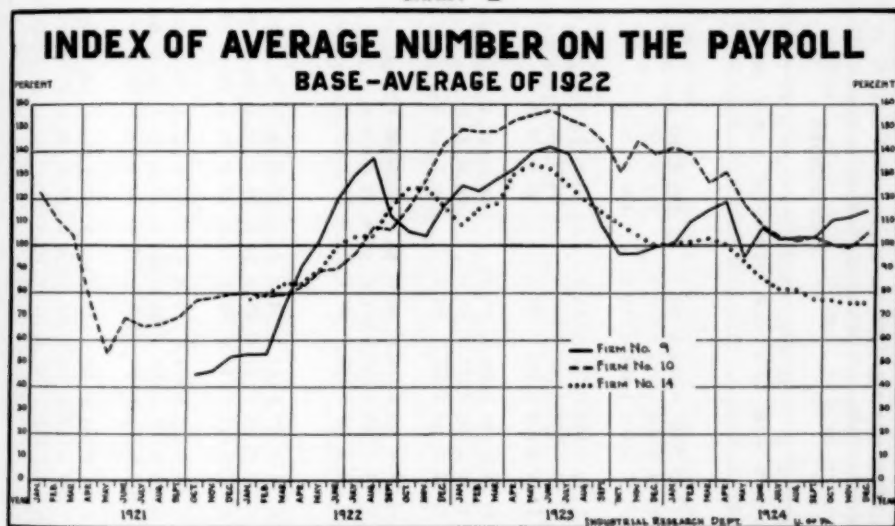
† Metal Firms, including shipbuilding.

A more extreme effect of the industrial depression in metal manufacturing plants appears in the index figures of Firms 7 and 11. Here the post-war adjustment along with the depression of 1921 caused a reduction in numbers of workmen so extreme that by December the firms employed less than one-third the number at work in

MORE COMPREHENSIVE SURVEY OF NUMBER ON THE ROLL

Since, at best, the number of firms reporting detailed data to the department cover only a *fraction* of the numbers employed in the area, it is necessary to supplement by more comprehensive data. Fortunately, for the

CHART II



January. No improvement occurred until November, 1922. Since that time the ebb and flow has resembled that of other metal plants. Firm 11 was less extremely affected by war adjustment but decreased until at its lowest point it had less than one-half the number enrolled in 1921. Recovery began in the second quarter of 1922 at the same time as it did in metal plants generally, and the movement since that date follows the firms on Chart II with a lag of one month.

The index numbers on Table 2 are based on the average of the twelve months in 1922. The figures show clearly how much less extreme was the effect of the depressions upon chemical plants than upon metal industries.

last part of the period, this is procurable from the bulletins of the Federal Reserve Bank in Philadelphia. The summary of their data shows that during the first three months of 1923, employment in the manufacturing industries of the Third Federal Reserve District was steadily increasing. January showed a marked improvement over the average of the preceding year and the next two months increased over January. Indication of increasing employment throughout the district did not necessarily mean that every individual industry was expanding at the rate of the whole. In many plants decreases were necessitated by the seasonal character of the product. In February, employment declined in

TABLE 2—INDEX NUMBERS OF NUMBER EMPLOYED BY INDIVIDUAL FIRMS
Base—Average 1922

MONTH	FIRM NUMBER																	
	1	2	3	4	6	7	8	9	10	11	12	14	16	17	18	19	21	
1921																		
January	106.1	69.4	126.1	69.3	167.0	425.4	93.7	...	123.2	190.4	...	...	...	...	...	...	...
February	103.6	77.7	119.8	66.7	163.1	414.9	112.9	...	111.9	189.3	...	...	...	...	...	...	...
March	102.6	76.8	118.5	67.2	163.1	402.9	111.8	...	104.5	176.3	...	...	...	...	...	...	...
April	101.1	79.6	117.2	78.3	152.0	377.0	111.7	...	76.5	171.6	...	...	...	...	...	...	...
May	99.1	80.2	115.7	84.0	132.4	347.2	100.1	...	54.7	166.2	...	...	...	...	...	...	...
June	97.7	82.6	113.1	82.2	128.5	328.7	83.4	...	69.4	157.8	...	...	...	...	...	...	...
July	99.2	85.3	111.0	88.8	110.1	294.8	77.4	...	66.0	147.4	...	...	...	...	...	...	...
August	99.5	87.9	109.4	86.1	102.2	211.8	81.2	...	66.9	133.0	...	...	...	...	...	...	...
September	99.2	90.2	107.3	82.0	94.4	184.1	85.4	...	69.7	113.0	...	...	...	...	...	...	...
October	98.6	93.0	106.8	78.5	93.9	159.0	96.0	45.3	76.8	105.4	103.0	...	...	...	...	...	...
November	98.1	92.6	107.3	75.1	95.0	138.0	107.2	46.8	77.6	103.2	...	...	91.1	109.5	43.2	...	...
December	97.8	95.0	107.0	*73.2	96.6	124.1	98.1	52.6	79.3	103.2	...	...	...	85.7	106.8	...	93.5
1922																		
January	96.6	96.7	104.2	71.2	97.2	124.1	91.0	54.0	79.9	99.9	98.3	77.0	97.7	103.0	58.6	104.4	88.8	
February	95.3	99.0	100.8	78.8	97.2	121.4	91.3	54.0	79.0	95.1	96.3	79.1	107.1	98.2	71.8	102.1	90.0	
March	93.9	98.1	100.3	86.9	101.1	110.6	92.1	73.3	79.3	90.5	95.0	83.2	103.3	93.0	90.3	99.3	91.3	
April	92.7	94.6	99.0	94.7	102.2	104.6	111.8	91.5	82.4	91.4	93.0	83.5	100.0	94.2	80.2	97.2	90.0	
May	93.1	98.5	96.9	100.6	102.8	100.4	108.0	102.4	89.2	98.7	92.2	89.2	100.0	93.5	85.0	97.4	102.2	
June	94.4	101.1	96.1	103.0	104.5	97.2	108.2	119.4	90.4	102.0	93.5	100.0	100.8	91.2	84.1	98.1	109.7	
July	97.7	102.5	96.9	104.6	103.9	93.8	105.2	129.8	97.2	104.8	95.1	103.3	104.1	90.2	96.0	98.3	105.5	
August	100.5	102.9	103.7	109.8	102.8	90.6	94.0	136.6	108.2	98.2	97.2	103.3	102.5	92.7	116.3	99.3	105.0	
September	103.4	101.5	101.8	106.7	101.1	87.0	94.6	112.8	107.1	97.4	98.8	115.2	101.5	101.5	119.8	99.9	101.7	

FOUR YEARS OF LABOR MOBILITY

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1923	October.....	107.9	102.3	97.1	110.2	96.6	86.6	100.7	105.7	110.4	102.7	105.0	124.1	95.2	111.8	116.7	99.9	102.0
	November.....	111.3	102.3	100.8	114.3	96.1	90.7	102.7	103.9	128.9	107.2	112.6	124.1	96.2	118.3	141.4	99.9	104.7
	December.....	112.9	100.5	102.3	118.9	96.1	92.9	100.7	116.8	143.6	112.4	123.2	116.8	89.1	114.8	140.5	104.7	109.0
	January.....	118.0	100.7	101.3	125.4	96.6	89.5	102.8	125.1	149.6	119.7	113.9	108.7	95.9	110.8	147.6	105.7	111.7
	February.....	123.2	102.9	101.0	129.0	95.5	90.3	109.1	122.9	148.7	123.1	118.1	115.4	102.8	107.5	147.6	105.8	109.9
	March.....	124.1	106.0	101.6	134.7	99.4	95.6	100.1	127.3	149.0	124.7	118.2	117.6	107.9	106.0	138.6	105.2	114.7
	April.....	123.6	104.9	99.2	139.2	101.7	95.9	102.1	132.2	153.5	122.6	115.8	130.6	105.9	106.0	110.1	107.6	114.7
	May.....	125.6	104.4	97.4	133.7	98.9	96.3	103.3	139.3	156.1	120.1	117.5	134.7	101.5	104.5	159.0	109.9	117.9
	June.....	128.0	103.5	101.3	129.4	98.9	95.9	99.1	142.1	157.5	118.6	120.2	132.8	109.7	108.5	138.3	110.5	114.9
	July.....	130.3	104.8	97.6	129.6	101.7	98.4	97.5	139.1	153.8	123.8	121.5	125.7	105.6	110.0	124.7	112.1	113.9
	August.....	131.5	104.3	98.4	130.2	106.7	99.7	99.4	124.7	151.0	128.7	118.0	119.5	109.2	110.8	123.8	96.3	111.7
	September.....	131.6	103.9	89.3	129.9	112.8	97.3	106.2	107.9	144.5	130.4	114.4	114.9	106.4	108.5	117.6	93.7	116.4
1924	October.....	132.0	99.4	85.9	137.6	120.1	95.6	110.3	96.6	131.7	133.7	118.1	108.4	101.8	106.5	115.0	96.1	106.0
	November.....	131.6	90.5	83.0	143.1	122.9	102.0	110.1	96.4	144.5	137.1	130.1	104.9	99.7	104.5	112.8	99.3	108.5
	December.....	129.9	94.7	80.2	143.6	125.7	111.4	107.8	99.6	139.4	135.8	131.6	100.5	105.3	103.3	111.9	98.9	111.7
	January.....	125.8	94.4	77.8	152.7	125.7	107.9	103.5	100.6	141.6	132.4	117.6	100.8	104.3	102.0	113.7	98.9	116.2
	February.....	122.2	91.7	76.0	147.3	124.6	102.5	102.2	110.1	139.4	132.3	114.6	101.4	110.9	103.5	116.3	99.7	120.6
	March.....	121.2	97.1	75.5	143.4	122.3	100.7	110.0	115.2	127.2	129.5	112.4	103.0	111.7	105.8	107.9	98.9	115.4
	April.....	120.3	98.4	75.5	139.2	117.9	101.8	116.3	118.8	131.4	128.2	112.6	100.5	111.4	106.5	83.3	96.8	113.4
	May.....	117.9	100.1	73.6	120.3	116.2	98.3	111.7	95.1	117.6	127.1	110.0	93.2	111.2	106.0	85.5	95.6	100.5
	June.....	114.8	99.0	74.4	102.2	116.2	97.8	109.4	107.5	108.5	127.0	108.6	86.7	109.2	105.0	101.3	94.9	78.1
	July.....	116.1	99.4	73.9	105.0	105.0	97.3	115.9	102.6	103.7	128.9	108.7	82.1	115.0	109.0	98.2	93.2	78.6
	August.....	118.8	83.0	74.9	111.8	102.2	96.2	126.5	103.6	102.5	127.6	109.5	81.6	102.3	113.8	104.8	105.8	73.1
	September.....	117.8	96.6	77.0	114.0	91.1	93.5	129.1	103.6	104.0	123.5	113.1	77.8	114.5	120.3	103.1	92.7	81.6
	October.....	116.7	101.3	80.2	126.0	90.5	95.7	130.5	111.7	100.3	116.3	118.6	77.0	108.1	125.1	104.0	91.2	72.4
	November.....	116.7	105.4	81.2	131.7	90.5	97.4	127.0	112.4	99.1	115.0	132.2	75.9	96.4	120.6	102.6	91.4	90.5
	December.....	115.8	108.5	83.8	133.7	90.5	99.9	134.5	114.8	105.9	115.9	137.9	75.9	107.9	115.3	113.7	92.0	101.7

* From estimated number.

the clothing, cotton goods, tobacco and boot and shoe industries. By March it was obvious that expansion had been far stronger in the manufacturing of production than of consumption goods. In April and May the sum total of employment had increased very slightly, yet in only six of thirty-one industries had the payrolls remained unchanged. Increases at this time were heavier in the large plants than in the small. Despite many seasonal decreases in June, the total employment showed a more marked increase that month than in the two previous. However, all gain was more than lost in July and there was no recovery in August.

Beginning with September, the figures cover all three of the states previously reported in part as the Third Federal Reserve District. Accordingly the number of industries discussed is increased by one-half and the number of plants is doubled. Instead of considering conditions in relation to those of 1922, increases and decreases are calculated on the preceding month. The 1 per cent increase of September over August was largely caused by the 9 per cent growth of the food and tobacco industries. The expansion in chemicals, building materials and textile products was not enough to off-set the decline in the food and tobacco group, and employment in the three states fell off slightly. The decrease continued the following month and doubled at the end of the year.

In general this picture of 1923 is the same as that given by the firms of Chart I, with July ending the period of quickening activity and the last

months showing a prevailing inverse movement. The decrease in employment at the end of 1923 was carried over into 1924 in various degrees through July with but slight increases in February and March. The decrease grew more marked in the early summer months. Even the seasonal increases, which had been noticeable the year before in certain large industries, were not sufficient to off-set the steady curtailment of operations in general. The expansion which began in August and continued to the end of the year, was not as rapid as had been the decline.

It is only in this increase in 1924 that the more comprehensive group of the bank's reporting differs from our curves. The bank reported an increase of about 1 per cent in numbers enrolled in August, 2.1 per cent in September, and 2.0 per cent in October. However, this was mainly in textiles and food products. Our textile, chemical and miscellaneous curves show these gains, but metals had no share in this recovery until the last month of the year. Even then the gain is fractional though prophetic of the beginning of improvement which the record of the early months of 1925 now shows to be substantial.

In general, then, firms were decreasing their payrolls through 1921, and the first part of 1922, increasing in the major part of 1922, and the first half of 1923, and decreasing moderately but steadily from the middle of 1923 throughout 1924 almost to the end of the year. It is into this period of extreme business upheaval that the study of labor turnover must be carried.

CHAPTER II

TOTAL TURNOVER RATES—ANNUALLY, QUARTERLY AND MONTHLY

The study of labor turnover started January, 1921, has now continued over a period of four years in a group of representative Philadelphia plants. At this time annual comparisons can be made of the yearly and monthly rates of loss of employees.

Considered by years the terminations were relatively high in 1921 owing to heavy lay offs in the first half of the year. In 1922 there was a drop to more moderate figures, five firms having a turnover well below 50. The year 1923 recorded higher figures for all, except six firms, than were their turnover figures in the previous year. One metal plant, three chemical and two merchandising plants were lower than in 1922. Turnover not only decreased in 1924 but dropped to a point lower than at any time in the last decade. By the end of the year little attention was being given to the problem. In this latter year nearly half the firms had turnover rates less than 60, while only two reached a figure of 100 or over. After the high rates of 1923, when most of the reporting firms had figures over 100 and two well over 200, the stability of the year 1924 is particularly worth noting.

As already stated, these summary figures are based on terminations for whatever cause divided by the average number on the roll. Much is gained by breaking up the total figure into the main divisions of turnover. The fluctuations due to lay offs can then be separated from resignations and discharges. These main divisions are given on Table 3. The extent of total separations indicates the volume of labor changes in a

plant but is of little significance until further analyzed. This study follows traditional usage and subdivides terminations into Resignations, Discharges and Lay Offs—a classification of separations according to whether the employe or the employer takes the initiative in bringing about the termination.

When an employe terminates his service with the company, the separation is classed under resignations. If the employer takes the initiative he either forces the termination for some real or fancied cause, classified under discharges, or on account of slack work, he lays the employe off temporarily or permanently. The line between these divisions is not always definite. Unsatisfactory employes may be continued until a period of poor operation when they will be laid off with no intention on the part of the employer to reinstate them when business recovers. Again an employe may not wait until a lay off occurs but may look for work elsewhere, thus anticipating a situation which would have otherwise counted as a lay off but is classed as a resignation.

Despite these qualifications resignations may be considered, in the main, as voluntary terminations on the part of the employe. In all years this group constitutes the largest item in separations and determines the contour of the turnover curves. That is to say that the elimination of lay offs reduces extreme peaks in monthly figures but rarely changes the months affected from those of high to those of low turnover. Resignations were low in 1921, high in 1922 and 1923 and moderate

TABLE 3—YEARLY TURNOVER RATES—TOTAL AND MAIN DIVISIONS, 1921-1924

Firm No.	TOTAL TURNOVER				RESIGNATIONS				DISCHARGES				LAY OFFS			
	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924
1.....	22.0	20.5	40.2	28.8	15.5	15.4	30.4	17.2	0.8	2.8	5.0	4.7	5.7	2.3	4.8	6.9
2.....	59.8	48.4	66.0	33.8	38.9	31.6	47.3	22.1	8.8	7.1	9.4	7.8	12.1	9.7	9.3	3.9
3.....	35.7	33.4	53.4	23.1	17.7	19.9	33.9	16.3	2.5	4.4	7.7	3.1	15.5	9.1	11.8	3.7
4.....	63.6	104.1	161.5	86.5	32.7	88.3	133.0	43.6	7.0	13.3	24.7	13.0	23.9	2.5	3.8	29.9
6.....	65.5	17.9	53.4	53.9	12.6	13.4	34.6	19.7	4.5	3.4	18.8	14.5	48.4	1.1	0.0	19.7
7.....	145.0	115.9	146.4	77.5	49.1	75.1	63.5	27.0	9.1	5.4	14.0	8.6	86.8	35.4	68.9	41.9
8.....	95.7	110.0	104.3	99.0	29.3	88.2	85.6	62.8	11.5	17.0	12.0	18.4	54.9	4.8	6.7	17.8
9.....	....	164.0	229.4	86.8	....	107.7	182.1	54.0	....	26.9	24.8	18.3	....	29.4	22.5	14.5
10.....	140.1	160.9	220.8	114.8	37.3	106.2	147.0	62.8	6.6	42.5	57.8	26.6	96.2	12.2	16.0	25.4
11.....	110.8	86.7	144.7	56.9	54.7	66.5	125.7	39.6	12.1	7.3	17.7	9.7	44.0	12.9	1.3	7.6
12.....	....	126.5	116.5	79.5	....	79.5	78.8	42.4	....	17.5	17.8	12.2	....	29.5	19.9	24.9
14.....	....	135.5	177.6	58.5	....	113.0	155.1	26.5	....	16.0	13.6	3.4	....	6.5	8.9	28.6
15.....	41.5	143.7	....	....	14.2	125.0	....	....	4.4	11.9	....	....	22.9	6.8	....	....
16.....	....	114.7	103.2	67.0	....	81.4	80.0	46.6	....	33.3	22.5	19.2	....	0.0	0.7	1.2
17.....	....	98.5	77.8	70.6	....	79.9	63.0	54.3	....	12.3	12.7	12.2	....	6.3	2.1	4.1
18.....	....	281.0	188.2	112.0	....	251.5	166.3	59.0	....	25.1	18.5	18.8	....	4.4	3.4	34.2
19.....	....	33.8	54.4	31.6	....	17.4	38.8	16.9	....	6.1	12.3	7.2	....	10.3	3.3	7.5
21.....	....	214.6	181.9	96.1	....	202.9	166.4	68.9	....	6.7	5.1	7.1	....	5.0	10.4	20.1
24.....	183.0	213.5	....	....	140.2	181.7	....	....	22.7	14.5	....	....	20.1	17.3	....	....

in 1924. The extent of resignations is significant when one considers that seven firms in 1922 and seven in 1923 had a turnover of more than 100 due to this cause, while only five firms had less than 50 in either year. Much of this high figure can be explained by the building up of payrolls and consequent loss of employees in the first weeks of employment.

Discharges tend to increase in a period when working forces are being built up, consequently discharge ratios were high in the last half of 1922 and the first half of 1923. The turnover for this cause was relatively low in 1921 and the first half of 1922. Only three of the small group of firms studied in 1921 had discharge rates of more than ten. In 1922 eight firms had ratios less than ten with three of these well under five. The largest concentration of firms was between five and fifteen. In the next year only four firms had an average less than ten with the concentration between ten and twenty. Even in 1924, when turnover for all causes tended to be low, discharges maintained a fairly high rate with five in the group above fifteen and nine in the group above ten. No conclusion can be drawn from these figures concerning the discharge rate in a less fluctuating period of production.

To some extent lay offs are a composite of many causes. Some of the firms were readjusting from a war-time

to a peace-time production. To this were added the depressions of 1921 and 1923. Temporary jobs constituted a third factor—a factor increased by small orders and fill-in jobs. How much of the lay offs was due to the aftermath of the war, how much to business conditions, how much to manufacturing conditions, no one can determine. In a few firms lay offs were the most important cause of separations but in the main they ranked next to resignations in causing turnover.

Combined figures for all firms will serve to summarize the importance of lay offs as a cause of turnover. Annual rates of turnover for all firms were as shown in Table 4. Nearly half the separations in 1921 were caused by lay offs. Fifteen per cent of the separations of 1922 and 13 per cent in 1923 were attributable to intermittent or reduced operation and resultant lay offs. Nineteen hundred and twenty-four had a poorer showing than the previous years with 29 per cent of the separations due to lay offs.

QUARTERLY TURNOVER RATES

The yearly computations obscure seasonal variation apparent in the quarterly and monthly data. Firms 1 and 2 are alike in having their highest turnover each year in the April to June quarter, except when the high turnover in March, 1921, raised the average for the first quarter in Firm 2

TABLE 4

YEAR	TOTAL TURNOVER	RESIGNA- TIONS	DISCHARGES	LAY OFFS	TURNOVER LESS LAY OFFS
1921 *	101.3	42.8	8.2	50.3	51.0
1922	95.6	70.4	10.9	14.3	81.3
1923	114.0	83.2	15.4	15.4	98.6
1924	64.1	35.1	10.3	18.7	45.4

* A smaller group of firms than is represented the following years.

and the January, 1922, figure raised the turnover of Firm 1. Firm 3 shows no consistent recurrence of the high figures in the same quarter of each year. Compared quarter by quarter turnover rates for these three firms were higher in the first three quarters of 1923 than in any similar period in the four years. For Firm 4 the highest period is the April to June quarter, 1923. Turnover had been low up to the end of June, 1922, but rose rapidly in each of the four following quarters and then dropped until the April quarter of 1924, when phenomenally high lay offs raised the turnover for the April to June quarter. The years 1922 and 1924 thus show very different movements which cannot be accounted for by seasonal peaks alone, since 1922 started low but increased during the year to a high figure. The year 1923 started high but dropped markedly by the middle of the year and continued to drop until the end of the March quarter in 1924. Barring the heavy lay offs in 1921, Firm 6 showed a low turnover until the end of 1922. The year 1923 recorded a rate three times that of 1922 with turnover high in every quarter, a condition which continued throughout the early quarters of 1924.

Firm 7 was affected by a severe shift from war orders to commercial work, consequently the whole year 1921 was characterized by heavy lay offs. The total turnover reached 284 in the July to September quarter. When lay offs are excluded there is a drop from March to the end of the year and an increase in 1922 and 1923 similar to that which occurred at other companies. Firm 8 differs in every respect from the group of firms with increased turnover in 1923, its yearly figure being slightly lower in 1923 than in the previous year. The April to June quarter shows a seasonal high peak in every year except 1923 when the quarterly

averages varied within a narrow range. Considered as a total, the highest quarter in the four years was due to lay offs in the spring of 1921. However, the two high quarters in 1922 are more significant owing to the persistence of a high rate over a long period.

During the last half of 1922 and three-fourths of 1923, Firm 9 reached a turnover figure so amazingly high that it may be regarded as out of accord with the experience of this firm in 1921 and 1924 or even in the first half of 1922. The April to June quarter in 1923 was about 330 percent whereas the previous quarter with a rate of 251 had been nearly four times the turnover of the corresponding quarter a year before. While figures for 1924 may not be considered as low, there was a tendency to more uniformity from quarter to quarter as well as a lower ratio of changes. From the spring of 1921, turnover for Firm 10 was downward until the first quarter of 1922. From then the tendency was upward with some seesawing from quarter to quarter until the high rate of 282 was reached in the April-June quarter, 1923. Lower figures characterized later quarters. The general upward and downward movement of Firm 11 occurred about one to two months later than that of other firms in the metal group, consequently the highest points of turnover occurred usually in the third quarter, raising the average for that interval each year except in 1923, when the high rate for May made the April to June quarter high. Firm 12, in the merchandising group, shows the influence of holiday trade and is the only firm with its highest quarterly averages in October to December every year. The direction of turnover changes at Firm 14 was comparable with Firms 9, 10 and 11 already considered.

For a year and a half beginning in 1922 there was no quarter in which the

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TABLE 5—ANNUAL TURNOVER RATES BY QUARTERS
Total, 1921-1924

QUARTER	FIRM NUMBER																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1921																								
Jan.-Mar.	23.8	87.5	62.8	51.7	42.2	78.9	67.3			94.0	125.4				18.7								120.9	
Apr.-June	35.2	63.3	37.1	42.0	126.7	127.2	181.0			394.9	95.5				48.6								224.0	
July-Sept.	14.9	51.3	22.9	88.8	65.5	284.1	47.8			63.8	159.9				36.6								186.7	
Oct.-Dec.	13.8	42.8	16.6	68.8	16.5	170.7	104.0	50.8	53.8	47.4					63.2	120.7*	48.7*						177.2	
1922																								
Jan.-Mar.	24.9	41.1	29.7	40.8	11.4	149.2	56.6	68.0	81.4	65.2	87.3	36.7	39.4	88.1			87.2	201.2	41.1	90.6	182.8			
Apr.-June	17.8	65.7	25.7	91.3	8.6	107.5	142.1	166.7	162.3	54.4	99.2	89.6	136.0	121.8			53.0	241.3	25.5	180.7	244.6			
July-Sept.	18.7	40.2	30.1	128.1	17.4	96.4	130.0	225.0	196.7	111.9	141.2	183.8	188.3	132.6			93.4	302.8	30.6	339.7	267.9			
Oct.-Dec.	20.6	47.0	48.0	136.5	34.9	100.9	104.2	143.7	179.4	111.6	169.7	192.4	183.9	117.7			148.8	331.1	37.5	229.8	167.6			
1923																								
Jan.-Mar.	39.6	55.0	49.5	189.2	43.7	129.9	109.6	250.9	269.2	127.1	113.8	200.0	140.0	79.8			66.9	212.3	49.7	179.2	202.2			
Apr.-June	52.0	79.8	74.7	213.2	62.6	170.7	103.3	329.5	282.2	196.6	113.2	265.8	362.0	119.5			98.3	313.0	66.5	253.2	199.3			
July-Sept.	44.6	68.1	53.9	140.3	56.2	161.3	106.6	207.3	198.1	167.6	89.7	144.2					79.6	127.1	54.2	151.1				
Oct.-Dec.	25.3	60.4	32.7	106.4	50.9	124.1	98.1	88.4	125.1	92.9	147.0	79.8					66.2	74.7	46.1	141.0				
1924																								
Jan.-Mar.	36.2	88.7	27.3	81.5	54.0	103.5	65.9	93.8	109.2	67.1	68.7	76.8					38.7	60.9	37.8	76.3				
Apr.-June	40.3	41.2	21.0	160.9	45.9	101.6	115.5	128.4	156.2	56.4	56.0	90.4					77.2	203.9	31.1	135.0				
July-Sept.	22.4	29.9	15.3	45.4	103.4	60.4	87.4	51.3	78.9	65.0	54.3	32.3					81.6	94.8	32.9	104.8				
Oct.-Dec.	15.9	25.7	28.4	58.0	9.9	42.1	122.7	72.7	110.3	37.2	130.8	22.8					81.8	103.3	24.1	72.1				

* For November and December only.

TABLE 6—ANNUAL TURNOVER RATES BY QUARTERS
Resignations, 1921-1924

QUARTER	FIRM NUMBER																							
	1	2	3	4	6	7	8	9	10	11	12	14	15	16	17	18	19	21	24					
1921																								
Jan.-Mar.	16.2	58.0	15.5	21.7	12.1	14.7	29.1		32.0	73.7			5.5						99.5					
Apr.-June	25.9	43.2	29.9	25.9	22.7	64.1	30.0		49.2	54.0			16.6						195.5					
July-Sept.	12.4	32.8	16.2	53.8	2.1	45.8	28.8		42.0	48.2			18.3						151.3					
Oct.-Dec.	7.5	25.6	8.8	26.2	9.4	35.1	36.6	9.8	30.5	30.5			17.2	*87.9	*25.0				107.9					
1922																								
Jan.-Mar.	14.8	25.9	7.2	30.0	9.1	53.2	30.1	43.1	41.4	29.3	50.8	23.1	17.9	60.4	57.4	162.9	9.2	68.5	145.1					
Apr.-June	14.2	38.8	15.0	76.9	4.3	81.5	113.1	137.9	105.2	46.1	74.4	76.4	122.2	75.1	41.1	213.8	19.2	171.8	195.4					
July-Sept.	15.6	26.8	19.7	111.7	13.1	83.4	110.4	115.6	121.7	84.5	111.1	104.6	173.0	95.0	79.6	290.0	18.3	332.0	244.5					
Oct.-Dec.	16.7	35.1	37.6	116.6	27.9	88.7	92.3	105.2	133.9	101.2	81.0	154.1	159.6	97.0	130.4	291.4	22.8	220.3	149.6					
1923																								
Jan.-Mar.	34.0	43.9	35.1	163.2	25.3	42.4	87.5	207.9	190.1	109.0	90.1	175.2	127.6	48.9	50.2	187.8	34.0	172.1	180.5					
Apr.-June	45.5	62.8	50.5	177.9	49.2	88.0	88.9	299.7	202.2	182.2	94.3	250.3	274.8	90.6	88.9	279.2	48.4	246.3	171.8					
July-Sept.	29.0	53.8	27.5	107.6	37.5	76.4	95.4	116.7	125.5	147.0	68.6	116.1		84.8	65.0	111.2	38.3	149.3						
Oct.-Dec.	13.9	26.7	20.1	86.1	27.3	47.0	71.8	65.7	62.2	70.5	63.6	57.0		94.5	48.0	63.8	33.8	93.4						
1924																								
Jan.-Mar.	21.6	26.1	19.1	46.2	23.4	30.5	38.1	72.0	63.4	45.6	43.0	43.7		48.6	30.0	34.4	18.4	63.6						
Apr.-June	22.0	22.4	12.6	60.7	19.1	36.2	82.1	53.9	60.0	43.8	38.5	24.3		51.5	64.6	58.8	18.4	77.7						
July-Sept.	13.9	20.9	12.5	27.8	27.0	23.5	56.0	34.5	54.8	42.6	38.8	18.8		41.4	62.3	60.3	16.4	79.2						
Oct.-Dec.	11.1	19.3	20.6	38.1	7.4	17.3	72.5	54.5	73.5	25.1	48.4	14.2		45.0	58.4	83.9	14.5	57.5						

* November and December only.

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TABLE 7—ANNUAL TURNOVER RATES BY QUARTERS
Lay Offs, 1921-1924

QUARTER	FIRM NUMBER																									
	1	2	3	4	6	7	8	9	10	11	12	14	15	16	17	18	19	21	24							
1921																										
Jan.-Mar.	7.0	17.8	43.0	26.1	21.8	21.8	18.9	60.0	30.5	8.8	29.6	10.7	1.8	4.9	51.1	15.3	18.5	12.0	30.8	14.4	22.4	2.1	2.3	1.0	2.1	2.3
Apr.-June	8.6	14.7	6.3	10.2	100.8	51.7	137.0	344.0	29.4	16.8	104.9	12.2	2.1	1.6	1.7	2.9	2.5	0.0	3.9	6.0	2.9	8.7	5.4	2.1	2.3	1.0
July-Sept.	1.5	8.3	2.9	22.0	59.0	233.8	8.2	62.8	29.5	4.4	14.3	41.4	40.0	15.3	18.5	12.0	30.8	14.4	22.4	2.1	2.3	1.0	2.1	2.3	1.0	2.1
Oct.-Dec.	5.5	8.9	6.8	38.6	7.1	133.7	62.8	29.5	4.4	14.3	41.4	40.0	15.3	18.5	12.0	30.8	14.4	22.4	2.1	2.3	1.0	2.1	2.3	1.0	2.1	2.3
1922																										
Jan.-Mar.	6.0	9.3	21.5	4.2	2.3	91.4	9.6	3.9	22.8	34.2	16.8	9.5	15.5	0.0	18.5	12.0	30.8	14.4	22.4	2.1	2.3	1.0	2.1	2.3	1.0	2.1
Apr.-June	1.5	19.4	7.5	1.0	2.15	20.1	3.8	0.8	11.6	1.3	6.3	0.0	7.9	0.0	5.4	2.1	2.3	1.0	2.1	2.3	1.0	2.1	2.3	1.0	2.1	2.3
July-Sept.	1.3	6.2	1.1	4.8	0.0	10.0	5.5	72.5	16.3	17.7	11.4	8.1	1.8	0.0	2.1	1.6	1.7	2.9	2.5	0.0	3.9	6.0	2.9	8.7	5.4	
Oct.-Dec.	0.8	4.1	6.3	0.4	0.0	4.2	0.8	21.1	2.6	0.0	74.8	8.0	4.3	0.0	0.0	3.9	6.0	2.9	8.7	5.4	2.1	2.3	1.0	2.1	2.3	
1923																										
Jan.-Mar.	0.4	1.9	7.2	0.0	0.0	68.1	5.6	3.8	8.4	0.3	6.9	4.8	0.8	0.0	3.7	2.3	7.3	0.9	5.6	0.0	3.9	6.0	2.9	8.7	5.4	
Apr.-June	1.1	5.0	13.7	5.8	0.0	68.6	2.9	2.3	1.5	0.2	2.3	0.0	52.6	0.0	0.0	3.9	6.0	2.9	8.7	5.4	2.1	2.3	1.0	2.1	2.3	
July-Sept.	7.4	4.4	17.6	7.6	0.0	71.0	1.7	72.1	25.7	0.0	2.8	19.0	1.9	0.9	0.9	2.9	2.2	0.0	0.0	0.0	3.9	6.0	2.9	8.7	5.4	
Oct.-Dec.	10.2	27.6	8.8	1.8	0.0	67.9	16.0	12.2	30.2	4.4	64.1	13.5	1.0	3.8	4.7	0.5	40.3	0.0	0.0	0.0	3.9	6.0	2.9	8.7	5.4	
1924																										
Jan.-Mar.	8.1	1.7	5.5	20.3	3.6	62.4	9.5	2.9	8.3	9.3	9.3	25.6	0.0	2.9	9.3	11.1	7.6	0.0	0.0	0.0	3.9	6.0	2.9	8.7	5.4	
Apr.-June	13.5	8.6	7.0	91.1	7.7	56.1	8.2	53.1	73.3	1.1	5.3	63.8	4.6	0.0	127.5	4.6	52.2	0.0	0.0	0.0	3.9	6.0	2.9	8.7	5.4	
July-Sept.	3.7	3.6	0.0	7.7	69.7	30.0	15.2	0.0	13.1	13.2	5.0	13.5	0.0	0.0	0.0	12.1	10.8	17.9	0.0	0.0	3.9	6.0	2.9	8.7	5.4	
Oct.-Dec.	2.2	1.5	2.6	2.9	2.5	17.2	35.5	2.1	4.5	6.8	72.5	5.7	0.0	11.7	3.3	3.0	3.4	0.0	0.0	0.0	3.9	6.0	2.9	8.7	5.4	

* November and December only.

rate of turnover for Firm 18 was less than 200. At the highest point in the last quarter of 1922 the figure was 331. The marked decrease in 1924 is interrupted only by the peak of the April to June quarter which reached 204 per cent. Firm 19 had a low turnover with little tendency to extremes in any part of the three-year period for which data are available. The general trend was upward throughout 1922 until midsummer of 1923. The last of that year began a downward movement which in 1924 caused quarterly rates of only a trifle over 30. In this respect despite its generally low turnover level the movement corresponds with that of other metal plants. The quarterly figures upon which conclusions are based are given in Tables 5, 6 and 7.

MONTHLY TURNOVER RATES

The monthly fluctuations of turnover are often more significant than the annual or quarterly data. To show the variations in rate of loss monthly, figures have been converted to an annual basis.² This monthly variation will be affected by seasonal factors as well as by the state of the labor market and business conditions. It consequently should be advantageous to compare the rates of firms working from the same basic raw material.

Monthly Turnover of Metal Plants.

Study of the metal manufacturing group shows that turnover increases or decreases at about the same time in a majority of the plants. The curves of separations for the trio of metal plants on segment C of Chart III show how similar is the direction of turnover movement.

² Some firms send in reports weekly and it is necessary to combine in such a way as to suit other production and cost records. Where the figures cover a four-weeks period, the number of terminations is multiplied by 13 to get the num-

Separations figures mounted steadily at each of the three firms while payrolls were being built up in 1922. The rate slackened during the early winter months—a seasonal feature which is found in the November and December figures of most plants. The next year the turnover mounted amazingly and held at a high figure for three consecutive months, March to June. By July, 1923, when opportunities for change of employment were lessened greatly, the curves begin to drop. The usual seasonal drop of November, December and January depressed the curves still further and gave March an appearance of beginning another swing upward. On the contrary, midsummer recorded low ratios and the year 1924 ended with six months of relative labor stability. These curves deserve more than passing comment. It will be seen that there is a considerable difference in the firms in the general level of turnover. This variation is doubtless due to differences in conditions within the plants. On the other hand the curves move upward at about the same time. This conformity is too regular for anyone to disregard the effect of market conditions upon the turnover of these plants. Without any apparent change in employment methods, turnover decreased in the last part of 1923. This should indicate to firms that any evaluation of methods calculated to reduce labor turnover should be made over a long period. A new project introduced in 1922 might have kept turnover from rising to as extreme peaks but could scarcely have

ber that would occur during a year at the same rate. If the figures cover a five-week period, the terminations are multiplied by 10.4. If the calendar month is used the multiplier is twelve. Quarterly figures are converted to an annual basis by multiplying the terminations in the quarter by four. The turnover rate is computed by dividing these adjusted figures by the average number on the roll for the period considered.

CHART III

ANNUAL TOTAL TURNOVER RATE BY MONTHS

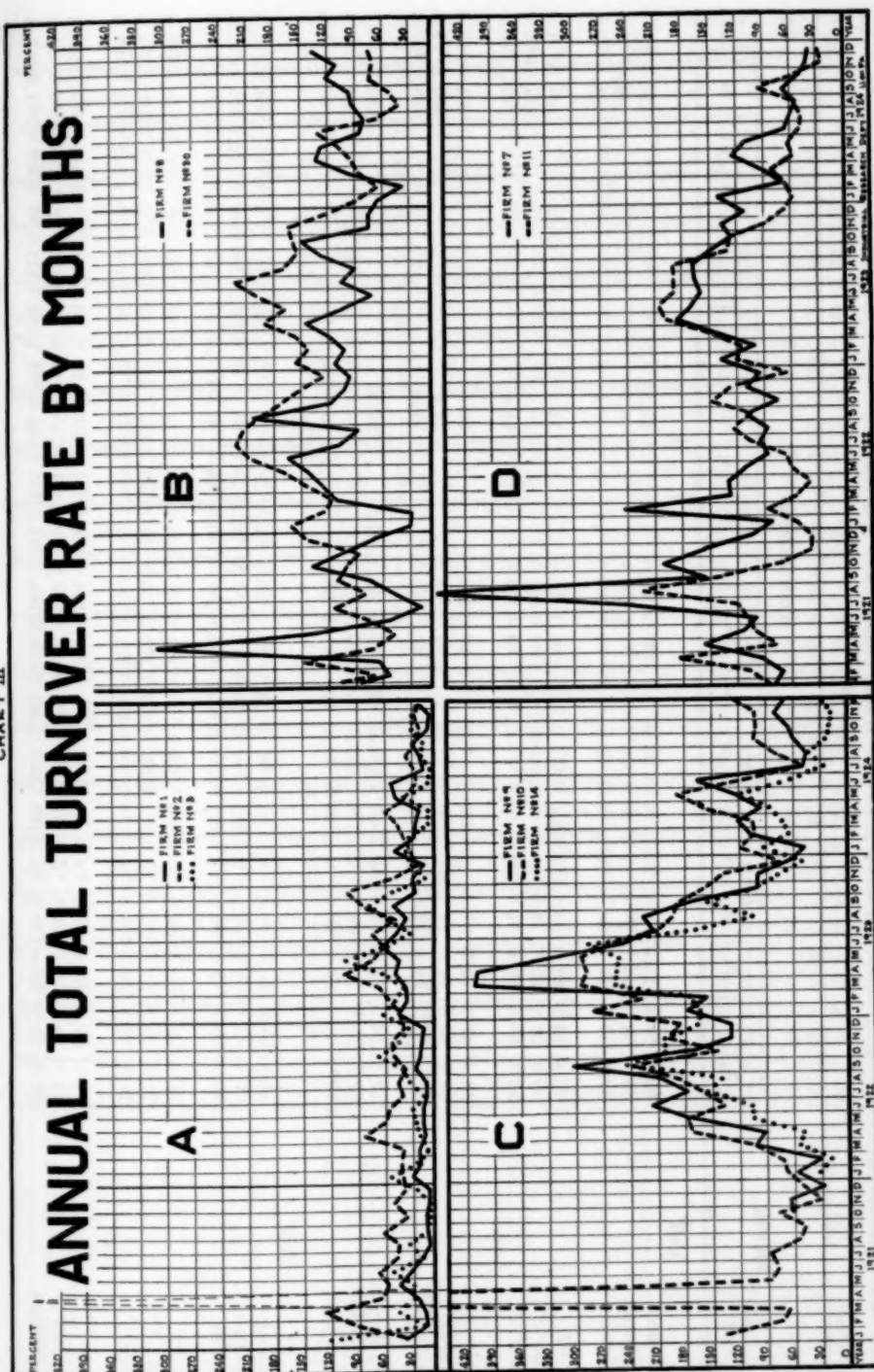


TABLE 8—ANNUAL TURNOVER RATES BY MONTHS
Total, 1921-1924

MONTH	FIRM NUMBER																			
	1	2	3	4	6	7	8	9	10	11	12	14	15	16	17	18	19	21	24	30
1921																				
January.....	39.7	36.9	121.8	69.0	32.1	77.0	86.8	....	137.9	88.4	....	....	42.8	....	....	....	....	....	112.2	106.6
February.....	15.7	92.7	15.7	53.0	12.3	68.2	54.3	....	72.9	108.6	....	....	3.3	....	....	....	....	....	52.5	69.9
March.....	17.3	127.9	47.4	33.0	82.2	92.3	63.9	....	65.0	183.2	....	....	9.9	....	....	....	....	....	184.1	148.1
April.....	26.4	64.3	29.4	38.0	145.6	156.3	311.0	....	902.2	77.4	....	....	72.0	....	....	....	....	....	204.3	71.1
May.....	46.3	57.9	29.7	36.9	35.4	112.8	140.8	....	87.0	101.2	....	....	36.4	....	....	....	....	....	217.9	48.8
June.....	33.6	67.7	52.6	51.1	198.3	97.0	54.0	....	78.4	108.8	....	....	61.0	....	....	....	....	....	245.5	74.3
July.....	19.4	47.5	19.7	67.1	0.0	238.5	17.8	....	87.5	119.9	....	....	52.0	....	....	....	....	....	164.0	114.5
August.....	10.7	45.4	34.3	88.9	177.0	453.7	47.8	....	55.9	224.8	....	....	25.9	....	....	....	....	....	203.2	79.6
September.....	15.7	60.7	14.5	112.3	21.3	155.4	74.8	....	48.8	135.7	....	....	34.6	....	....	....	....	....	190.7	107.6
October.....	16.1	36.5	11.7	115.4	35.7	201.1	138.3	62.9	79.7	68.1	91.6	....	53.9	....	....	....	....	....	156.5	98.1
November.....	12.6	53.3	11.6	54.6	7.1	156.7	103.9	65.8	30.6	37.1	....	....	106.9	114.0	52.3	146.9	....	....	205.7	87.3
December.....	12.9	38.9	26.3	*33.5	6.9	104.8	70.2	27.0	51.4	36.5	....	....	25.9	128.2	45.2	....	....	28.7	163.7	144.8
1922																				
January.....	30.2	40.0	54.1	31.6	6.9	81.1	30.3	57.1	68.1	53.2	79.3	33.8	18.1	71.9	99.5	117.3	7.9	60.5	204.0	162.4
February.....	21.7	43.9	24.9	36.8	0.0	245.6	28.8	30.8	73.1	87.7	79.4	20.6	60.7	65.6	110.5	235.6	66.5	72.9	154.9	123.2
March.....	23.0	39.4	9.4	51.8	26.5	127.8	110.2	103.5	102.8	54.6	103.4	54.7	39.2	127.1	48.6	228.3	50.0	137.3	190.4	116.4
April.....	15.6	83.7	22.2	68.2	0.0	129.0	126.6	93.3	173.2	37.9	104.0	50.6	58.7	70.2	60.8	303.3	15.3	119.3	180.8	144.7
May.....	18.8	59.8	25.9	83.5	13.0	111.6	136.8	173.7	179.0	58.8	106.5	105.8	165.5	204.6	61.3	242.5	25.5	201.5	290.8	170.9
June.....	18.8	54.8	29.4	120.0	12.8	86.5	163.2	216.6	135.4	64.8	87.1	107.3	170.6	90.9	36.4	182.2	35.4	212.2	274.8	207.3
July.....	14.4	39.5	16.1	98.0	12.9	94.6	105.9	177.2	161.0	105.5	104.9	137.5	157.2	94.0	56.8	236.7	20.2	333.9	219.1	221.2
August.....	14.7	44.0	33.2	125.7	0.0	86.9	86.6	204.9	188.5	125.8	143.2	141.7	160.0	134.0	84.6	340.9	31.7	355.4	308.0	214.1
September.....	27.6	36.9	40.0	159.9	39.8	110.7	200.0	304.7	238.0	104.7	174.1	245.6	242.6	171.4	133.7	317.6	39.8	328.6	273.2	190.4

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1923														
October	32.8	51.8	67.7	156.2	48.6	75.5	116.8	172.7	146.0	148.5	104.0	204.3	206.9	106.8
November	19.9	51.8	43.5	177.7	41.9	110.5	101.2	180.0	200.4	126.2	97.1	204.4	148.3	107.9
December	18.7	37.3	33.7	78.7	14.0	95.1	94.5	129.9	187.0	63.8	202.1	167.0	104.2	75.4
January	45.7	43.2	61.9	183.2	27.7	137.9	110.8	178.2	281.8	119.2	102.4	164.6	100.0	63.7
February	35.7	54.9	49.6	165.7	42.1	99.8	101.1	156.3	228.6	115.0	105.5	174.6	74.2	59.4
March	36.7	66.3	37.0	217.4	60.7	149.9	117.6	413.6	296.6	146.7	133.0	237.1	230.6	113.2
April	49.1	105.6	63.2	159.7	46.2	186.0	137.4	410.7	290.0	197.1	134.0	256.4	363.5	118.3
May	44.5	73.0	102.9	249.9	94.9	168.3	103.0	335.3	294.0	205.3	110.3	253.5	272.3	132.3
June	63.0	60.4	58.8	232.7	47.5	158.1	68.3	248.6	203.3	187.0	96.1	286.5	467.4	108.6
July	46.8	73.8	32.1	134.0	19.8	165.3	104.1	214.8	212.1	187.2	69.5	168.1	232.2	124.3
August	36.0	46.8	54.1	168.3	81.7	166.8	89.5	226.3	193.6	188.2	83.3	106.0	...	100.7
September	50.3	83.7	77.2	118.6	65.3	149.5	125.1	175.8	188.2	128.8	117.7	155.6	...	83.3
October	27.4	101.8	51.0	152.0	55.8	124.1	146.5	100.6	160.0	125.7	86.4	105.0	...	129.0
November	30.1	53.3	15.1	95.5	54.5	135.5	73.9	100.8	141.2	88.3	84.6	80.6	...	61.2
December	17.7	23.9	31.3	73.5	42.7	111.3	73.1	64.3	75.6	65.0	263.1	51.8	...	136.2
1924														
January	49.4	32.1	36.2	65.2	74.7	139.9	64.1	47.2	120.0	57.4	79.3	93.6	...	67.3
February	28.1	38.3	33.0	98.2	26.9	68.2	36.8	107.7	102.4	65.4	51.1	64.2	...	49.5
March	26.9	45.4	12.5	81.7	60.3	89.5	94.5	121.4	104.2	78.7	75.5	72.6	...	98.4
April	22.9	60.5	12.5	140.9	68.3	124.9	132.5	95.8	160.3	57.8	62.1	87.3	...	65.8
May	48.9	37.5	38.3	135.6	40.4	111.3	127.8	124.7	190.8	62.2	59.1	118.6	...	76.9
June	53.8	25.8	12.6	217.9	28.8	65.6	84.7	167.6	112.8	49.1	46.8	63.8	...	89.5
July	16.8	27.6	8.5	37.2	127.7	60.4	77.8	48.6	49.2	46.5	41.5	27.7	...	45.1
August	21.2	37.3	20.9	44.8	32.8	53.5	90.1	45.8	82.9	53.8	53.1	43.9	...	68.7
September	30.5	25.9	16.3	53.6	154.6	67.2	93.1	59.5	104.6	96.0	67.6	25.1	...	61.3
October	12.4	22.9	31.3	56.8	14.8	48.2	121.0	65.8	101.7	57.9	61.5	21.1	...	64.9
November	10.5	28.8	30.9	61.6	0.0	39.3	111.4	82.2	102.9	24.7	65.7	17.1	...	60.2
December	20.7	25.2	23.1	55.8	14.8	37.8	135.0	70.2	125.1	28.8	252.9	30.0	...	56.6

* Estimated.

prevented a general tendency to increase. On the other hand, if one were fortunate enough to make the change in the early part of 1923, turnover would have moved steadily downward and continued low, for a year and a half. To conclude that the change reduced labor turnover is to mistake symptoms for causes. While prediction is dangerous, the chances are that the rate of turnover will increase somewhat in the year 1925, and a recognition of the market factors influencing this increase will be the surest guarantee against delay in readjusting to prevent a more extreme increase.

The turnover for Firms 7 and 11 differed from the group already considered only in the lay offs of 1921. Besides, though the contour of the curves in segment D of Chart III was the same as those of segment C, the general level was lower after 1921. At the highest point in 1923 Firm 7 had a rate of 186 with Firm 11 at 205. The high peaks of segment C were 414, 296 and 287. This period in 1923, when turnover remained high and curves moved horizontally for about three months, is of interest since it characterized the curves of all our metal plants.

These five plants differ widely in type of finished product. They differ somewhat in location. They are more or less dependent on the same grades of skill, though in varying proportions. The degree of regularity in the trend of turnover in the past three years suggests a high degree of similarity from month to month in the direction which turnover is likely to follow. It would not be safe to assume that once payrolls were built up the firms would show similarity over an extended period of regular production. The phenomena, so characteristic of these curves, may be brought about by the high turnover among newly hired groups. After organizations were built up would the

figures be more dominated by factors within each plant than at present? Answer to such an inquiry must be delayed for study of a larger group of plants over a longer period.

Monthly Turnover of Chemical Plants

The time of the upward and downward movement in chemical firms showed less correspondence than was found in metals. With the exception of one firm the highest figures occurred in 1922 when the turnover in metal plants was low. The low points occurred in the winter months in each year. During the rest of the year the fluctuation was most irregular with high points at midsummer. On the whole, turnover was low in 1924 and the last months of 1923, a condition already stressed in the metal group. To illustrate the general character of this movement, total turnover rates at two large chemical plants are given in segment B of Chart III. The firms are very different in character of product though classed in the same major group. None of the chemical group were subjected to as high turnover as most metal plants. The influence of seasonal variation appeared more marked than any long-continued tendency toward low or high rates.

Monthly Turnover of Textile Plants.

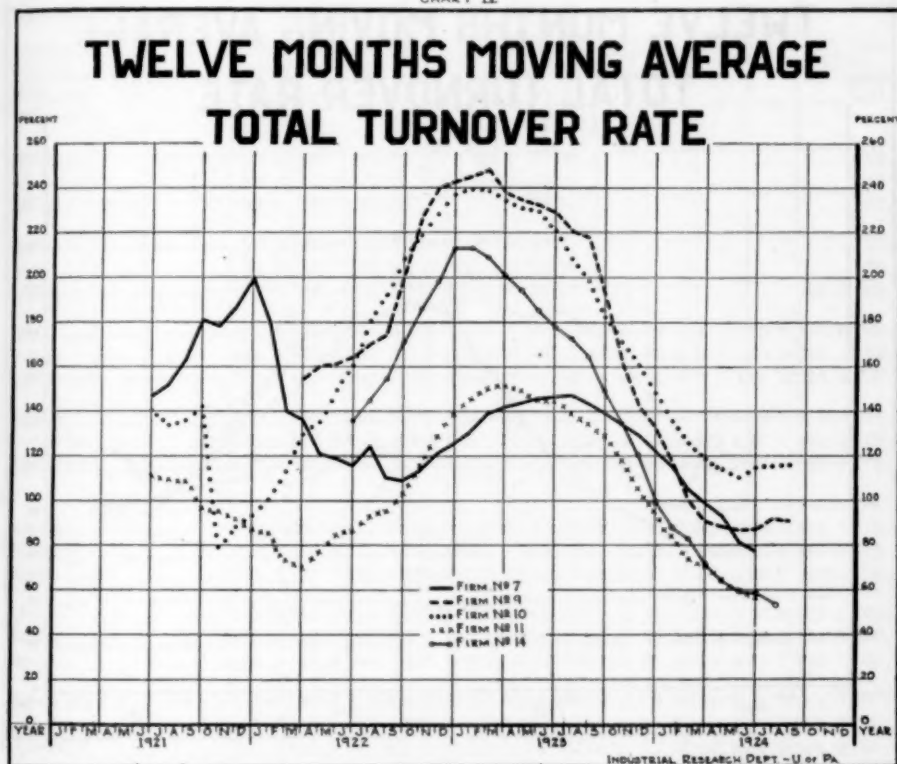
Production changes during the past four years in the small number of textile plants included in this study were gradual. The turnover was low during most of the period though 1923 was considerably higher and 1924 lower than other years. Seasonal high peaks occurred each year in the early spring months. The only exception to this was an additional high peak in October, 1923, occasioned, in part, by lay offs. These plants are making unusual efforts to stabilize production and their turnover cannot be assumed

to represent that of textile plants in the locality in general. The curves on segment A of Chart III are illustrative of this group and show a moderate range in turnover rates. Despite some increase in 1923 the curves are unusually regular and controlled. In general it

TURNOVER TREND AS SHOWN BY TWELVE MONTHS MOVING AVERAGE

Monthly figures represent the rate at which separations were taking place during a given month, computed on an annual basis. The monthly figures re-

CHART IX



may be concluded that seasonal fluctuations are more apparent in the chemical and textile data than in that of the metals with July to August highest in chemicals and March to May highest in textiles.

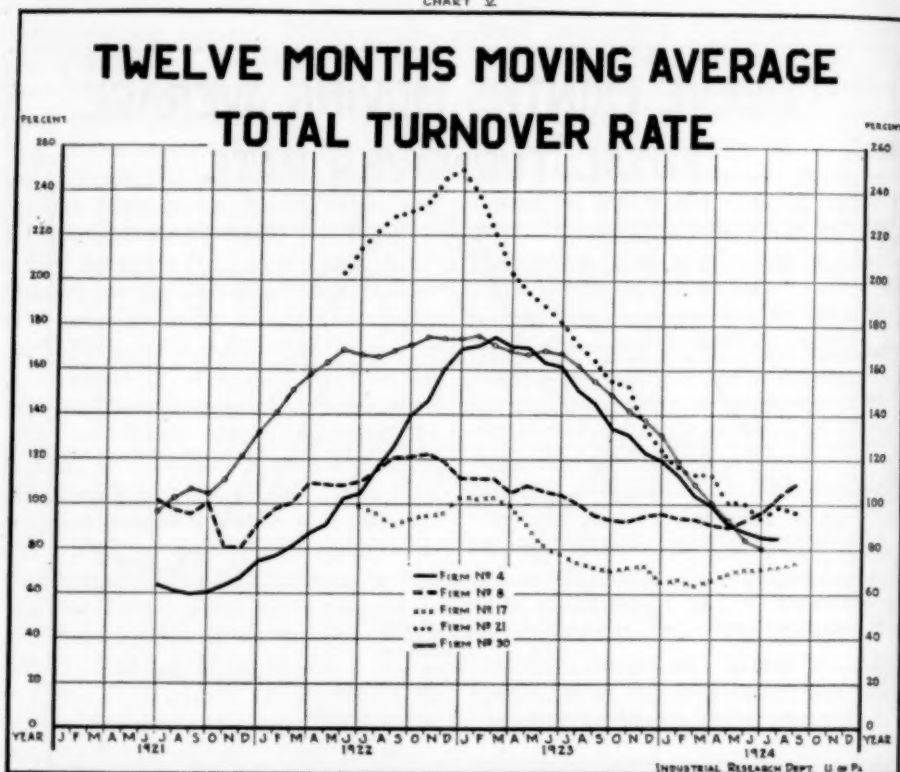
The monthly figures upon which charts are based appear on Table 8. The main divisions of these totals are essential for interpretation and are published in Appendix B of this study.

flect the immediate situation and indicate the *rate* of loss. No one means to claim, however, that turnover for the rest of the year actually does continue at the same rate. Undue emphasis to extreme figures can be avoided by computing an average of twelve months by accumulating the monthly figures. Figures have been cumulated for the turnover by starting with the first twelve months available and continu-

ing a moving average for each twelve months following. This, of course, eliminates the extremes and smooths out the monthly irregularities but does give a figure based on the total experience of the twelve months period. It is a truer long time record than the more

average. From then there is a marked upward movement until April of 1923—a figure which reflects the experience of the twelve months, October, 1922, to the end of September, 1923,—when all curves begin to move more downward. The similarity in direc-

CHART V



detailed statement, but of less value as a short time indicator.

The moving averages plotted for metal firms on Chart IV lead one to emphasize more strongly than monthly charts the similarity of the movement of turnover in this group of plants. The turnover for the twelve months has been plotted in the middle of the period, consequently the point on the chart indicated for July first is the actual turnover of the whole year. All firms in 1922 start with a relatively low

tion of movement was already certain from the monthly and quarterly figures. What this chart makes more evident is the persistence of a low or high level of turnover at any given firm throughout the period despite the upward and downward swings. Firm 10 starts above the curve of 14 in 1922 and continues from month to month the disadvantage with which it started. If a coefficient of correlation be computed for these two firms there is a marked positive degree of correlation amounting to

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TABLE 9—TWELVE MONTHS MOVING AVERAGE OF TOTAL TURNOVER RATE, 1921-1924

MONTH	FIRM NUMBERS											
	4	7	8	9	10	11	14	17	18	19	21	30
<i>1921</i>												
July.....	63.6	146.7	101.6	....	140.1	110.8	....	....	....	....	....	96.9
August.....	60.8	151.8	97.2	....	133.8	109.9	....	....	....	....	....	102.5
September.....	59.3	168.2	95.9	....	136.2	108.8	....	....	....	....	....	107.7
October.....	60.4	180.5	100.3	....	142.0	96.6	....	....	....	....	....	104.8
November.....	63.0	177.7	81.9	....	78.8	95.2	....	....	....	....	....	111.1
December.....	67.3	186.5	81.8	....	88.1	91.7	....	....	....	....	....	121.4
<i>1922</i>												
January.....	73.9	199.8	91.6	....	93.1	87.4	....	....	....	....	....	132.2
February.....	76.9	179.0	97.7	....	100.4	85.1	....	....	....	....	....	141.0
March.....	81.0	139.0	100.2	....	112.8	73.0	....	....	....	....	....	151.2
April.....	86.4	136.0	109.9	154.5	129.9	69.7	....	....	....	....	....	157.9
May.....	91.3	120.7	108.2	160.0	135.0	76.6	....	....	....	....	....	163.3
June.....	102.3	118.5	108.1	161.2	149.6	84.5	....	....	....	....	203.3	168.2
July.....	104.1	115.9	110.0	164.0	160.9	86.7	135.5	98.5	281.0	33.8	214.6	166.8
August.....	116.1	123.6	116.0	170.0	180.7	92.6	144.7	96.3	280.3	36.8	222.4	166.2
September.....	125.8	110.1	121.2	174.3	192.2	95.2	154.9	91.6	271.3	35.4	228.6	168.1
October.....	139.7	108.8	121.8	199.8	208.4	103.1	170.8	92.7	271.6	36.1	231.8	171.3
November.....	146.5	113.2	122.5	226.1	218.8	116.4	186.3	94.2	280.1	40.0	235.4	174.9
December.....	160.6	121.2	119.7	239.9	228.5	128.7	197.9	96.4	285.9	43.6	246.1	174.5
<i>1923</i>												
January.....	169.9	125.2	111.5	242.9	237.4	138.6	212.5	102.8	286.7	46.6	249.4	174.5
February.....	171.9	130.9	111.5	245.9	239.4	145.5	212.6	102.1	278.5	47.6	237.3	175.4
March.....	174.9	138.8	111.6	248.0	238.4	150.8	208.9	102.8	263.0	48.9	220.3	171.8
April.....	171.2	141.6	105.9	238.4	234.3	151.9	201.8	99.1	247.1	52.2	203.3	168.5
May.....	170.6	143.5	108.6	234.2	234.8	149.8	194.4	90.8	215.6	54.9	194.5	167.2
June.....	163.2	145.9	106.3	232.7	229.5	145.8	185.2	81.9	204.0	54.7	188.1	168.3
July.....	161.5	146.4	104.3	229.4	220.8	144.7	177.6	77.8	188.2	54.4	181.9	167.6
August.....	150.8	146.8	100.4	220.9	207.9	139.1	172.5	74.3	175.5	53.4	171.6	162.2
September.....	145.0	143.7	95.2	217.9	197.9	134.7	164.3	72.3	165.8	51.2	164.2	155.2
October.....	133.6	139.0	93.3	192.2	182.4	129.1	149.3	70.9	151.8	51.6	155.5	149.5
November.....	132.0	134.4	93.4	163.3	171.3	117.8	134.5	71.6	148.7	48.4	152.8	142.1
December.....	122.7	129.2	95.6	142.6	161.1	106.5	120.9	72.3	125.9	45.8	135.2	137.6
<i>1924</i>												
January.....	119.9	122.3	96.8	133.3	147.9	95.7	99.7	65.6	112.5	42.4	124.8	131.8
February.....	113.3	115.7	94.5	117.5	135.3	84.5	87.7	66.6	107.0	42.7	117.1	118.9
March.....	103.9	104.0	94.4	100.8	125.9	73.5	82.9	63.8	102.9	40.5	113.7	108.9
April.....	99.0	98.0	91.9	90.9	118.5	70.7	71.5	66.3	103.8	37.1	113.6	100.6
May.....	90.9	93.4	90.3	88.0	113.8	64.9	64.8	68.6	108.9	33.0	101.3	93.1
June.....	87.9	83.4	93.5	86.5	110.1	59.8	59.9	70.5	110.7	32.0	101.0	84.8
July.....	86.5	77.5	99.0	86.8	114.8	56.9	58.5	70.6	112.0	31.6	96.1	80.8
August.....	85.8	....	103.8	92.1	114.9	....	53.0	72.2	119.1	30.7	98.7	....
September.....	....	....	108.7	91.1	116.0	....	....	74.7	130.5	....	96.8	....

0.99. While this is a case of extreme similarity the position of other curves makes one wish for some study of the general levels over a long period. Evidence on this point is important. It is fairly clear that the upward and downward swings depicted in the charts cannot be controlled within any one plant. However, the persistence of a level higher than other plants within the same industry and labor market measures a situation dependent upon wage and working conditions and within the control of the plant.

Evidence in the turnover of chemical plants is less conclusive than in that of metal. The firms with high turnover levels tend to approach each other in the

last part of 1923. The firms were not so extremely affected by depression conditions and the turnover does not reach the extremes of the metal group. So far no conclusion is warranted concerning the separate influence of plant and market factors.

All the moving averages tend downward after March, 1923. For two of the firms this represents a slight decline from figures that were already low; for three other firms the downward drop is substantial and the low points of the June, 1924, average result from a year or more of steady decrease in turnover rates.

Moving averages upon which charts are based appear on Table 9.

CHAPTER III

MAIN DIVISIONS OF LABOR TURNOVER

The total turnover discussed in the previous chapter included resignations, discharges and lay offs. The total figure shows the loss of employes in terms of the potential risk; it does not give any indication of the nature of separations until the primary divisions into causes of turnover are known. Lay offs predominated in 1921 and 1924, the years of decreasing payrolls, but had an influence in many months of other years in some of the plants. These figures reflect the general spotty character of production conditions and may be said to weight the total figures by a factor due mainly to manufacturing and business inactivity though in actual amount they are normally a small proportion of the total.

How much of the synchronous movements already stressed in total turnover are due to the inclusion of lay offs in the figures? This question can be most easily answered by plotting rates of resignations—a division which comprises about three-fourths of all terminations.

Chart VII, p. 36, shows resignations for the same group of firms compared on Chart II for number on the payroll, and segment C, Chart III, for total turnover. Here the conformity appears accentuated instead of lessened. The high points in 1923 are reduced from 414, 296 and 287 respectively to 371, 219 and 279, but these are still extreme rates at the end of a year and a half of rising rates followed by a sudden drop to extremely low figures. The resignation rates are more subject to seasonal variation than the totals, consequently dips are noted at mid-summer of each year. Again in November and December rates tend to be

lowered. This seasonal variation causes the drop in curves at the end of 1922 and explains the only significant difference in the contour of the resignations curve when compared with the totals. Firms 7 and 11 would be regarded as plants with low turnover normally, yet in the peak of 1923, turnover for resignations alone reached nearly 200 per cent at Firm 11, while at Firm 7 resignations barely touched 100 per cent. Despite this difference in extreme items there are few months when in general form the direction of movement is dissimilar. In both curves on Chart VIII, p. 36, the high rate holds over a period of about five months followed by five months of steadily decreasing rates. Nineteen hundred and twenty-four, by contrast, is uniformly low with scarcely a peak rising above 40 for either firm.

This discussion stresses only the outstanding items. The monthly changes may be more easily noted from the table of resignations by firms, Table 10.

Resignation curves at four plants widely different in type of product are given on Chart IX, p. 37. In all firms the turnover rates are low. Here the dominating influence is the rhythmic recurrence of low figures in the early summer months and again in November and December. Reduction of turnover in these plants is largely a matter of lowering the annual recurring peak between these two periods of seasonal lull in rate of resignation.

In the chemical group on Chart X, p. 37, there is between firms no clear nor easily explained relationship. In some cases resignations are extraordinarily high, yet these same plants drop to quite negligible rates in 1924. Further

TABLE 10—ANNUAL TURNOVER RATES BY MONTHS
Resignations, 1921-1924

MONTH	FIRM NUMBER																			
	1	2	3	4	6	7	8	9	10	11	12	14	15	16	17	18	19	21	24	
1921																				
January.....	18.8	23.2	14.9	20.0	8.0	39.3	26.7	....	22.1	46.8	....	....	13.2	....	....	....	....	....	87.8
February.....	14.3	66.6	15.7	22.0	12.3	37.6	27.7	....	30.4	45.8	....	....	0.0	....	....	....	....	....	26.2
March.....	15.5	80.6	15.8	22.0	16.4	59.3	32.5	....	45.5	132.5	....	....	3.3	....	....	....	....	....	108.2
April.....	22.7	45.6	26.7	28.0	22.1	71.7	38.2	....	66.6	51.5	....	....	10.3	....	....	....	....	....	178.5
May.....	26.2	34.8	27.0	22.0	30.3	62.8	19.6	....	55.9	60.1	....	....	36.4	....	....	....	....	....	191.1
June.....	28.5	49.0	36.0	27.4	15.7	52.7	30.0	....	24.5	50.1	....	....	28.7	....	....	....	....	....	213.2
July.....	18.3	34.2	11.2	48.5	0.0	42.9	11.3	....	46.3	46.1	....	....	8.0	....	....	....	....	....	136.4
August.....	8.3	33.3	28.7	59.9	0.0	42.1	27.8	....	40.7	51.1	....	....	18.5	....	....	....	....	....	159.0
September.....	11.6	31.0	8.7	53.1	7.1	51.5	45.5	....	39.0	47.6	....	....	27.7	....	....	....	....	....	156.9
October.....	9.4	21.8	8.8	33.8	14.3	31.7	47.0	21.0	44.3	41.1	66.4	....	38.1	....	....	....	....	....	151.4
November.....	6.6	27.6	8.7	27.3	7.1	42.4	31.5	0.0	13.1	25.7	....	....	6.9	77.1	38.5	134.7	....	....	118.8
December.....	6.8	27.6	8.7	17.1	6.9	24.9	31.9	9.0	34.3	24.5	....	....	3.7	99.7	11.3	....	....	....	50.9
1922																				
January.....	20.3	28.3	3.0	17.6	6.9	35.1	12.4	30.8	38.3	24.7	52.1	25.4	10.9	53.1	79.0	81.2	4.7	23.5	153.0	
February.....	10.1	22.3	12.5	30.5	0.0	53.2	19.2	13.2	30.1	23.4	42.5	20.6	14.3	37.1	49.1	206.1	6.5	69.6	134.4	
March.....	14.2	27.3	6.3	39.7	19.9	70.3	58.5	74.4	55.7	40.3	57.9	23.4	28.5	91.6	42.2	181.5	16.6	111.2	148.5	
April.....	13.2	25.8	12.7	55.5	0.0	88.7	87.4	72.6	123.7	29.8	68.7	38.9	52.2	24.4	44.8	263.7	11.9	106.1	139.4	
May.....	13.4	49.6	9.7	71.1	6.5	83.6	117.1	145.9	137.1	50.1	85.8	83.9	157.2	155.7	45.2	217.6	17.0	189.8	222.1	
June.....	16.5	40.6	22.8	102.0	6.4	74.2	135.4	180.8	56.4	57.0	68.7	100.8	145.0	45.45	33.1	163.4	28.7	209.5	255.9	
July.....	12.9	25.0	12.9	86.1	12.9	75.0	82.1	137.0	94.5	72.5	76.4	126.0	145.6	47.0	50.1	231.2	10.1	314.1	207.1	
August.....	11.2	31.3	15.1	115.7	0.0	76.8	70.6	116.3	97.4	88.1	105.4	122.8	149.3	92.3	74.8	322.7	13.3	355.4	297.1	
September.....	23.6	24.0	30.8	132.7	26.5	101.1	181.5	90.4	171.4	93.9	150.1	237.2	219.6	147.4	109.6	304.4	31.5	325.7	237.5	

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1923																			
October	18.9	39.6	54.8	134.0	48.6	70.6	104.4	100.9	116.8	134.7	88.4	178.1	184.8	147.6	175.3	452.8	28.2	351.2	200.3
November	16.6	36.7	31.1	152.3	27.9	99.2	90.2	109.5	147.7	117.6	82.2	149.4	137.5	79.4	145.2	220.5	31.5	145.4	179.1
December	14.1	29.0	27.5	66.1	7.0	76.2	82.1	105.6	134.9	55.0	73.6	133.6	154.3	61.7	70.9	229.5	9.5	169.9	67.7
January	39.9	34.9	55.7	158.4	6.9	34.2	86.5	151.6	215.9	100.6	74.2	140.6	94.6	35.0	54.5	186.2	22.0	171.0	137.1
February	29.7	42.8	24.8	144.3	35.1	34.5	80.4	133.1	134.9	94.4	83.8	169.0	61.4	44.5	44.8	146.8	37.5	154.7	101.2
March	31.6	53.4	24.7	185.8	33.7	59.8	96.3	335.4	219.0	131.3	111.6	212.9	212.7	65.1	51.1	226.7	42.4	190.0	163.2
April	45.0	88.6	47.4	125.9	33.0	100.3	123.9	371.3	219.2	183.5	111.9	246.4	331.0	75.0	68.2	398.4	41.5	177.0	146.4
May	36.5	49.0	67.5	205.4	74.6	89.1	89.7	308.1	209.1	188.8	98.6	224.5	243.3	114.3	80.8	279.2	51.2	216.4	268.1
June	54.9	50.6	37.1	205.3	40.7	74.3	51.9	225.3	179.1	174.0	73.2	279.2	252.2	83.5	116.7	183.4	52.4	244.2	100.2
July	32.9	56.2	22.5	106.6	13.2	76.8	98.9	187.5	101.6	166.7	51.3	139.7	132.0	92.5	41.1	118.7	20.6	186.0	135.4
August	20.6	38.8	25.5	123.3	36.8	79.0	75.6	89.4	153.1	164.2	60.3	92.5	.....	89.5	76.2	111.0	92.7	141.6	.....
September	32.6	66.5	35.1	90.9	35.6	72.3	110.9	57.1	122.3	111.3	95.6	113.2	.....	71.8	77.8	103.4	65.4	120.5	.....
October	16.4	37.1	43.8	125.1	27.9	55.2	126.0	58.9	56.8	107.2	63.1	87.0	.....	123.0	82.1	55.2	62.0	126.8	.....
November	16.3	29.6	3.8	74.5	43.6	55.5	46.6	78.7	84.7	64.9	61.4	65.1	.....	52.0	40.3	79.7	28.3	60.6	.....
December	8.3	13.2	11.7	60.3	10.7	30.4	41.8	59.5	43.9	40.0	66.2	16.2	.....	107.2	20.5	56.7	11.7	93.5	.....
1924																			
January	28.2	17.6	24.2	35.7	32.0	28.7	37.5	30.7	62.4	40.6	48.1	35.5	.....	55.6	26.6	18.6	10.1	56.5	.....
February	16.9	24.0	20.6	39.7	16.1	24.4	20.8	84.0	70.7	41.1	33.4	44.9	.....	22.0	23.3	22.7	14.9	81.6	.....
March	17.4	36.2	12.5	65.9	21.9	38.9	54.7	96.7	56.1	55.3	47.3	50.5	.....	68.3	39.9	63.7	30.1	51.7	.....
April	19.2	21.2	8.3	77.6	34.1	40.6	78.6	65.9	62.0	42.4	41.8	42.0	.....	43.9	73.6	50.8	15.4	81.6	.....
May	31.7	26.2	21.3	44.5	11.5	41.1	114.4	84.8	72.3	47.6	39.6	17.4	.....	57.7	79.6	74.2	24.2	80.2	.....
June	15.4	19.8	8.4	56.8	11.5	25.6	52.7	13.2	43.9	41.3	34.1	11.3	.....	53.1	40.2	52.1	15.7	68.8	.....
July	9.2	21.6	8.5	21.5	44.7	24.6	55.1	39.3	26.2	36.4	27.1	7.9	.....	26.5	49.8	69.9	8.9	79.7	.....
August	14.6	26.6	16.7	31.8	32.8	22.9	58.4	32.1	59.7	42.6	38.4	23.9	.....	44.8	50.3	35.3	14.1	93.8	.....
September	19.2	15.4	12.2	29.9	0.0	22.6	54.3	32.0	78.4	49.0	50.4	25.1	.....	53.3	85.2	76.9	26.8	65.8	.....
October	8.1	19.4	23.5	39.7	7.4	22.8	73.9	42.5	61.0	37.2	48.6	8.4	.....	48.0	108.0	106.8	21.8	90.7	.....
November	6.7	19.8	15.5	39.9	0.0	13.5	57.2	67.5	65.2	18.3	55.5	12.8	.....	38.0	37.5	77.2	7.2	59.3	.....
December	15.6	18.6	23.1	34.8	14.8	14.5	85.6	53.7	93.0	19.7	41.3	21.4	.....	48.1	26.1	69.8	14.4	32.3	.....

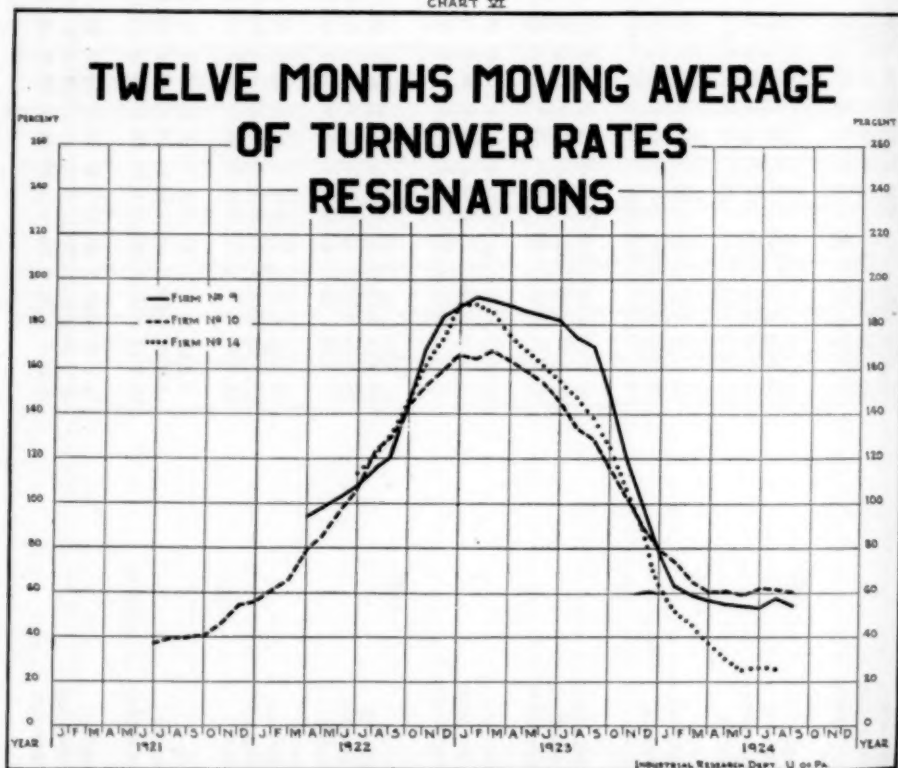
reference to the cause of these differences must be delayed until major reasons for leaving are considered.

In the main, the resignation curves show that separations on the initiative of the employees were highest in 1923 in metal plants, and in 1922 in chemicals. In the latter group the seasonal variation is greater than in metals. Low resignations characterize the early winter months and pre-vacation months in women's industries with the exception of Firm 12, where high resignations occur in early summer months, whereas its high lay offs are just after the Christmas season.

From this analysis of resignations the synchronous movement noted in total turnover curves cannot be explained by the inclusion of lay offs. Resignations constitute not only the largest

item in separations but determine the general contour of the turnover curves. That is to say that the elimination of lay offs reduces extreme peaks but leaves the period of increasing turnover unaffected and months of total turnover are usually months of high resignations. In reaching this conclusion there is no reason to minimize the importance of lay offs. While in any year considered lay offs make up only a small part of the total separations, these items are relatively of much social importance since termination for this cause is likely to occur at a time when other plants are reducing and when new employment is not easily secured. Loss of employment without any chance of minimizing the effect by forethought on the part of the employee cannot be regarded as a minor social

CHART VI



problem. For this reason monthly rates of lay offs are given in Table 1 of Appendix B. A companion chart of the twelve months, moving averages of resignation rates is given for the metal plants shown in Chart IV for total turnover rates.

The elimination of discharges and lay offs not only reduces the curves but flattens them out and tends to bring the lines closer together. The curves cross and recross each other in the upward climb in resignation rates in 1922. By April, 1923, the beginning of a downward slope is unmistakable in all curves. In this drop, one of the curves responds slowly while others decline more precipitously. The groups approach each other closely by October in a drop that brings two of the averages below 60 and one as low as 25.

There are many ways of explaining the high resignations of 1922 and 1923. The reductions of 1921 had been drastic enough to extend to employees whose production was satisfactory. When orders increase it is the usual practice to give these former employees first opportunity to return. In many cases

their return to a former position means vacating one held in the interim for a longer or shorter time. The frequency of "return to former position" in the causes for leaving shows that this factor was important. Again, some firms changed the character of production or manufactured some specialties which required a different proportioning of grades of skill in the plant. In these cases new men were hired though others were being laid off, or more probably quitting because of transfer to a kind of job which they regarded as less desirable than their previous one. The acceptance of smaller orders than would normally be booked necessitated much hiring for temporary work. Besides, any building up of payrolls is subject to abnormally high losses in resignations and discharges. The employer can wait usually until he can find an employe with the qualifications he regards as essential for filling a position. The employe looking for work has no such ability to wait until he finds the kind of work and the kind of organization he desires. The first job that offers must be taken. Earlier search for

TABLE 11—TWELVE MONTHS MOVING AVERAGE
Resignation Turnover Rate

FIRM NO. AND YEAR	MONTHS											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Firm No. 9:</i>												
1922.....				94.6	98.2	103.3	107.7	115.3	121.1	143.0	168.6	183.3
1923.....	187.6	192.0	190.3	188.2	186.0	184.4	182.1	174.0	170.7	149.7	121.5	99.5
1924.....	78.8	63.8	58.6	56.5	55.2	54.4	54.0	57.5	54.7	.....	.....	.....
<i>Firm No. 10:</i>												
1921.....							37.3	39.3	39.6	40.5	45.9	54.3
1922.....	56.5	61.1	66.3	78.9	85.3	97.3	106.2	123.3	129.9	143.6	152.5	159.0
1923.....	166.9	165.0	168.1	164.1	159.4	154.1	147.0	134.5	129.5	116.4	103.2	91.1
1924.....	79.4	73.8	65.0	60.4	60.8	58.7	62.8	62.1	60.6	.....	.....	.....
<i>Firm No. 14:</i>												
1922.....							113.0	121.2	131.5	146.0	162.2	173.2
1923.....	188.2	188.3	185.1	175.4	168.6	162.7	155.1	147.5	138.1	125.0	107.2	88.6
1924.....	63.3	51.6	45.6	37.3	30.5	25.9	26.5	24.9	.....	.....	.....	.....

CHART III

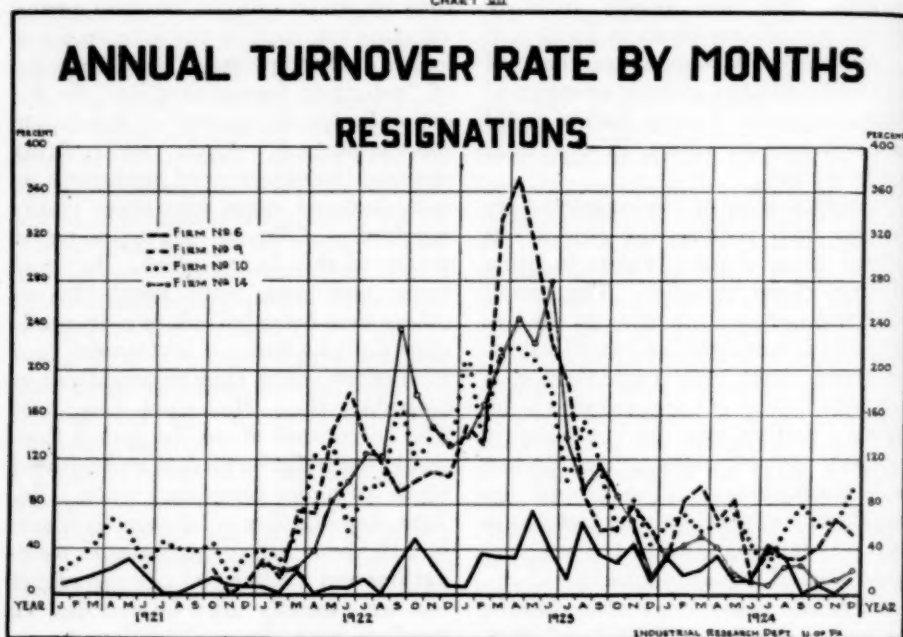


CHART IV

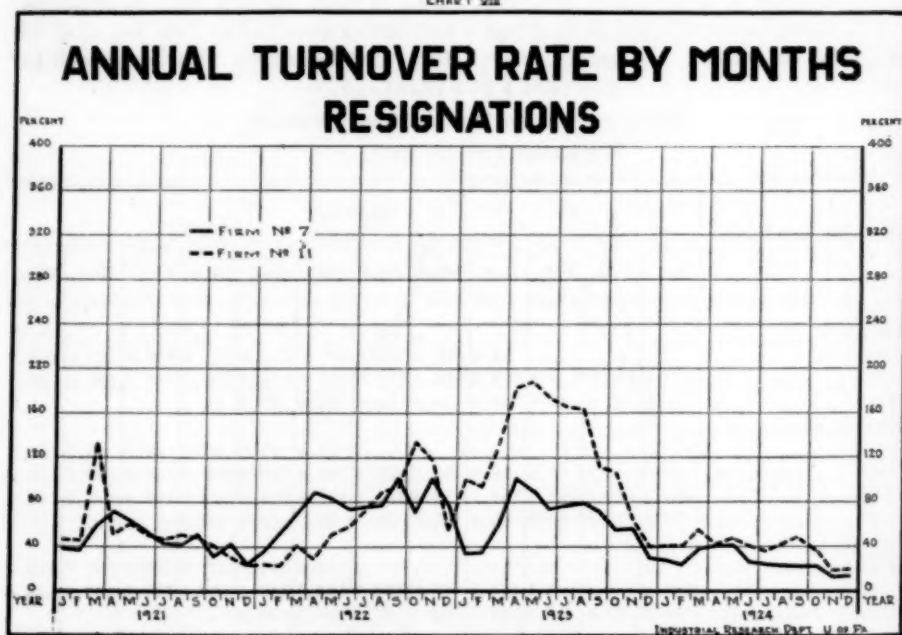


CHART II

ANNUAL TURNOVER RATE BY MONTHS RESIGNATIONS

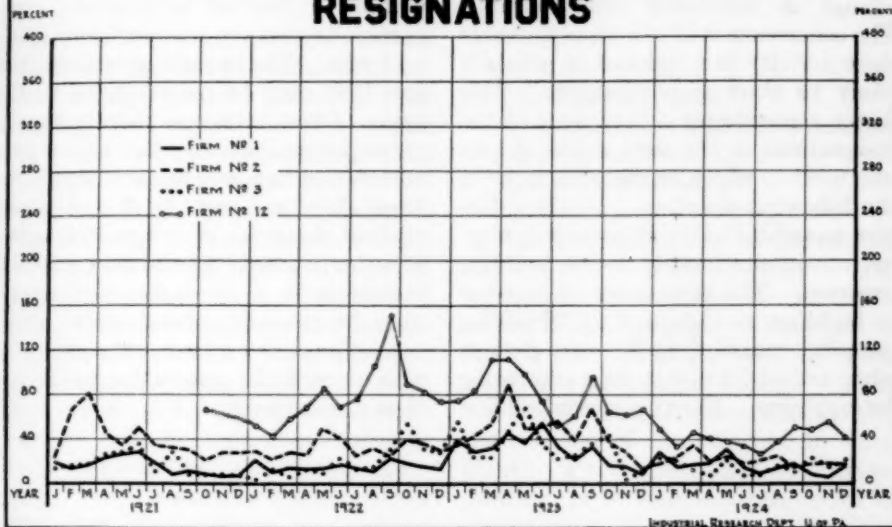
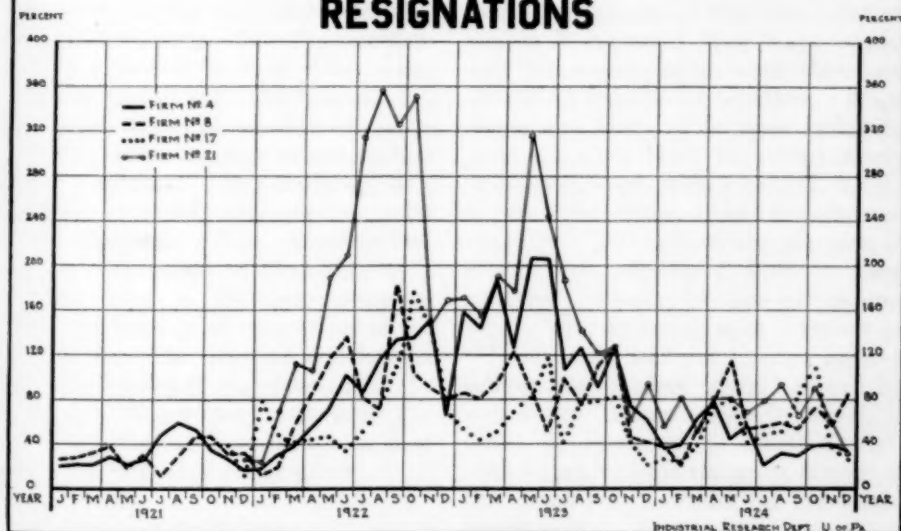


CHART III

ANNUAL TURNOVER RATE BY MONTHS RESIGNATIONS



employment may result in notice of some work he considered more desirable only after he has already accepted the first opening. When the offer comes change is inevitable and desirable. The occurrence is all the more probable since activity in a number of plants is likely to start simultaneously. This factor accounts for a large part of the resignations in the first weeks of employment to which attention is given in the following chapters. To these factors was added in the Philadelphia market an extraordinarily active building program. The percentage of increase in building, as indicated by "building permits" was high in the very periods when industrial plants were competing for employees. Fluctuations in building

activity are shown on Chart XXVII.

After the payrolls have been somewhat stabilized it might be possible to continue even in a period of activity without a rate of resignations comparable to that experienced in building up forces. The increasing rates of 1922 and 1923 may be more related to the ratios of new entrances than to the increase in production. For this reason no attempt has been made to apply refined statistical tests to the apparent cyclical character of resignation rates. Whether turnover lags behind business indicators in a decreasing period and precedes in a rising period, or vice versa cannot be answered without such use of refined methods over a longer period than our data cover.

CHAPTER IV

MAJOR REASONS FOR SEPARATIONS

The main divisions of turnover were classified according to whether the employe or employer took the initiative in causing the separation. No single point of view can be maintained in grouping major reasons under these divisions. In reporting to the Research Department, firms are requested to list all reasons in detail, retaining as much of the atmosphere of the shop as possible. Often two or three causes operate in bringing about a separation and no one can determine which is the main cause, since all the circumstances combined to make the separation desirable. This is likely to be true of many resignations: wages, hours and distance of the plant from his residence, all operating to lead an employe to find another position or to return to one formerly held.

Even causes of discharge are not single and definite. An employe's work may be below average, but along with this he may be regarded as surly, or lazy, or he may walk about the shop instead of working. It is the combination of apparent lack of effort along with low production which causes his discharge, whereas another employe with the same average of production may be retained. In tabulating it is not easy to classify such reasons under single headings. The classifications give an impression of simplicity to a problem that is infinitely complex. This overlapping of causes must be kept in mind in drawing conclusions from a grouping of major reasons. In so far as such grouping is possible, the Industrial Research Department uses nine subdivisions of resignations:

- (3) Hours
- (4) Labor policy
- (5) Work elsewhere
- (6) Community and family reasons
- (7) Personal reasons
- (8) Physical reasons
- (9) Unknown

The first four deal with the relation of the employe to his own plant. Terminations of employment for these causes are, in the main, due to dissatisfaction with earnings, working conditions, or management policy. "Work elsewhere" covers causes dealing with the relation of the employe to other plants. Leaving to return to a former position, or to learn a trade, or for an opportunity "to work at his own trade," would all be tabulated under this heading. In many cases the plant to which the employe is going is recorded. The difficulty with the classification is that many items recorded merely as "other position" occur. Doubtless most of these are wage causes. Analysis of this classification makes it apparent that wage causes and items grouped as work elsewhere should be considered together. Wage causes are likely to be more definitely given in piece work industries where workers quit when they cannot, within a reasonable time, reach the average earnings. Throughout the grouping of resignations, attempt is made to keep in mind the point of view of the employe. For instance, such a reason as "Thought he was not treated right—seldom made piece work," would be put under "Labor policy," though it could be regarded as dissatisfaction with wages, or from the point of view of the employer it would be inefficient production.

- (1) Wages
- (2) Working conditions

Many illustrations could be given of the difficulty of separating wage causes from other reasons for resignation. However, there is an important difference, as Mr. Slichter states,

between men who leave because of a better opportunity and those who dislike their jobs so intensely that they are unwilling to remain at them. Those who give "better jobs" as a reason for leaving are attracted by a definite place. They may have no objection to the job which they are leaving. They leave simply because the new opportunity is more attractive. The men who leave because dissatisfied usually are not attracted by any particular opportunity for usually they have no definite job in prospect. They leave because they are so dissatisfied with their job that they feel certain of being able to obtain a better one.¹

If this shade of distinction really can be made it would be important to separate employees who are leaving to accept another position from those so dissatisfied with rates or earnings or uncertainty of the amount to be paid, that they leave without assurance of a new job, and take the chance that one can be secured. At any rate, the heading "wages" in this study includes only separations where specific complaints of dissatisfaction with wages were recorded. The much larger item covering "other position," "better opportunity," "to better self," and "former position" may be just as truly wage dissatisfaction as the first heading though expressed in more optimistic terms. The recognition that a distinction could be made does not warrant one in assuring the reader that it has been made. The figures may be indicative of a trend even though the exact proportion under any one major cause be doubtful.

The best justification for assuming any reliability for the classification is

¹ Slichter, Sumner H. *The Turnover of Factory Labor*, p. 166.

furnished by the internal evidence in the figures themselves. There should be no reason for community and family causes increasing from year to year in the same firm because turnover increases. Between firms there will be differences in this item dependent upon whether the firm employs women or men. The same may be said of physical reasons. On the other hand, the periods when business conditions are active should be periods of increase in "work elsewhere," and wage items. Turnover for dissatisfaction with working conditions tends to be high for chemical plants and departments of other plants subject to fumes, gas or moisture. In chemical plants this item should increase markedly in periods of active demand for labor. With the conditions of the market in mind these data for major reasons for leaving can be tested on Table 12.

In Tables 12 and 13, major causes for leaving are given for each year, 1921-1924 inclusive, computed by different methods. Table 12 gives the percentage of separations based on average number on the roll due to each of the major causes. While this arrangement shows the actual turnover due to any cause, the amount of any one cause would be low if the general level of separations in a firm were low. To show the proportions actually caused by each reason, Table 13 gives a subdivision on the basis of the proportion of each total due to any one cause. To facilitate comparison material is arranged by firms instead of chronologically.

WAGE CAUSES

Some significant differences in the causes of separations occur in the four-year period. In 1921 only two firms had any considerable proportion of separations specifically laid to wage causes—all other firms show one per

TABLE 12—YEARLY TURNOVER RATES ACCORDING TO MAJOR REASONS FOR LEAVING,
1921-1924

YEAR	RESIGNATIONS									DISCHARGES		LAY OFFS	TOTAL
	Wages	Working Conditions	Hours	Labor Policy	Work Elsewhere	Community and Family	Personal	Physical	Unknown	Incompe- tency	Disciplinary		
Firm 1:													
1921	0.03	0.71			5.1	1.6	6.1	1.9	0.06	0.8		5.7	22.0
1922	0.2	2.47		0.03	6.3	1.1	2.8	2.4	0.1	1.6	1.2	2.3	20.5
1923	0.9	9.0	0.1	0.1	11.8	2.0	3.5	2.3	0.6	2.0	3.0	4.9	40.2
1924	0.1	1.5		0.2	8.2	1.4	3.3	1.9	0.6	1.7	3.0	6.9	28.8
Firm 2:													
1921	0.3	4.5	0.3	0.3	6.2	7.2	7.7	6.8	5.6	8.8		12.1	59.8
1922	0.3	4.6	0.2	0.8	6.2	4.4	6.1	6.3	2.7	2.4	4.7	9.7	48.4
1923	0.6	5.9	0.9	0.4	11.2	5.0	11.1	6.2	6.1	4.8	4.5	9.3	66.0
1924	0.2	2.3	0.2	0.5	5.0	2.7	4.9	1.9	4.4	3.7	4.1	3.9	33.8
Firm 3:													
1921		1.2			6.2			0.2	10.1	2.5		15.5	35.7
1922		1.8		0.3	5.0	1.8	2.9	2.6	5.5	2.1	2.3	9.1	33.4
1923		2.7		0.6	6.6	3.9	5.8	2.7	11.6	4.7	3.0	11.8	53.4
1924		0.7	0.7		3.7	0.7	3.7	5.1	1.7	2.7	0.4	3.7	23.1
Firm 4:													
1921	0.6	6.6			11.6	0.2	5.2	8.5		7.0		23.9	63.6
1922	1.9	23.5			30.1	3.7	6.8	13.8	8.5	5.1	8.2	2.5	104.1
1923	18.0	30.7			28.1	4.8	14.7	16.8	19.9	3.6	21.1	3.8	161.5
1924	4.1	7.7			9.8	1.4	6.1	7.9	6.6	2.9	10.1	29.9	86.5
Firm 6:													
1921	0.5	0.9			8.1		1.8	1.3		4.5		48.4	65.5
1922				0.6	10.7		0.6	1.2	0.6	2.7	0.5	1.0	17.9
1923	2.1	4.2		1.1	23.0	0.5	0.5	0.5	2.6	13.6	5.3		53.4
1924		2.6		1.6	10.4	0.5	2.6	1.0	1.0	9.8	4.7	19.7	53.9
Firm 7:													
1921	0.7	1.4			8.8	0.2	7.6	30.4		9.1		86.8	145.0
1922	1.5	2.4		0.7	18.1	0.5	6.5	45.5		1.8	3.5	35.4	115.9
1923	4.1	4.5			23.2	0.7	11.3	19.7		3.6	10.4	68.9	146.4
1924	0.7	2.0			13.3	0.1	3.8	7.1		1.2	7.4	41.9	77.5
Firm 8:													
1921	0.2	2.0		0.3	14.0	1.6	1.7	2.8	6.7	11.5		54.9	95.7
1922	0.2	5.6		1.1	32.2	2.9	2.0	2.8	41.4	9.5	7.5	4.8	110.0
1923	1.5	9.2		1.6	35.3	4.1	0.5	4.6	28.8	4.4	7.6	6.7	104.3
1924	1.1	4.8		0.4	19.6	1.0	4.0	2.5	29.4	8.3	10.1	17.8	99.0
Firm 9:													
1922	6.5	16.0	0.6	3.8	51.8	2.2	6.5	7.3	13.0	8.5	18.4	29.4	164.0
1923	20.7	26.9	1.1	6.7	77.8	4.1	10.0	13.9	20.9	9.3	15.5	22.5	229.4
1924	2.7	8.3	0.9	1.1	25.8	0.6	4.0	7.3	3.3	7.9	10.4	14.5	86.8
Firm 10:													
1921	13.2	2.8	2.5	5.9	3.8	3.8	1.8	2.8	0.7	6.6		96.2	140.1
1922	11.6	16.2	1.7	2.8	30.9	6.5	12.7	12.5	11.3	15.3	27.2	12.2	160.9
1923	11.8	43.3	2.7	4.6	43.1	11.1	12.6	10.7	7.1	12.0	45.8	16.0	220.8
1924	8.4	5.4	0.5	1.7	19.2	7.9	8.1	7.2	4.4	7.9	18.7	25.4	114.8

TABLE 12—Continued—YEARLY TURNOVER RATES ACCORDING TO MAJOR REASONS FOR LEAVING, 1921-1924

YEAR	RESIGNATIONS									DISCHARGES		LAY OFFS	TOTAL
	Wages	Working Conditions	Hours	Labor Policy	Work Elsewhere	Community and Family	Personal	Physical	Unknown	Incompe- tency	Disciplinary		
Firm 11:													
1921.....	6.6	4.6	1.0	....	22.8	1.8	7.9	3.8	6.2	12.1	....	44.0	110.8
1922.....	4.2	7.0	0.4	....	31.9	2.8	6.6	2.9	10.7	7.3	....	12.9	86.7
1923.....	12.0	10.2	0.9	0.5	41.4	6.6	15.8	4.9	33.4	17.7	....	1.3	144.7
1924.....	2.2	2.1	0.4	1.3	18.1	2.2	5.0	2.0	6.3	3.0	6.7	7.6	56.9
Firm 12:													
1922.....	4.1	6.3	0.4	1.9	32.6	8.7	8.3	5.5	11.6	8.0	9.5	29.6	126.5
1923.....	1.4	7.5	0.2	3.0	27.4	8.4	9.3	5.3	16.3	7.2	10.6	19.9	116.5
1924.....	0.4	3.9	0.1	2.2	15.5	5.2	6.6	3.4	5.1	5.9	6.3	24.9	79.5
Firm 14:													
1922.....	57.5	15.2	0.3	2.4	28.4	1.1	4.8	2.2	1.1	7.6	8.4	6.5	135.5
1923.....	28.1	40.3	1.6	5.3	47.0	4.8	10.4	2.1	15.5	6.7	6.9	8.9	177.6
1924.....	1.2	2.5	0.3	6.2	9.9	0.3	4.9	1.2	....	2.5	0.9	28.6	58.5
Firm 17:													
1922.....	18.8	12.8	0.5	2.3	12.1	8.3	6.3	4.0	14.8	4.8	7.5	6.3	98.5
1923.....	9.6	6.3	0.2	1.2	12.4	4.7	8.0	5.6	15.0	3.5	9.2	2.1	77.8
1924.....	5.4	4.5	0.5	2.0	14.7	4.5	4.8	7.2	10.7	4.1	8.1	4.1	70.6
Firm 18:													
1922.....	38.3	39.2	...	5.3	66.9	8.8	5.7	12.8	74.4	13.7	11.5	4.4	281.0
1923.....	16.5	28.3	0.3	8.1	52.5	4.0	11.1	5.1	40.4	7.7	10.8	3.4	188.2
1924.....	6.8	8.1	...	3.9	24.4	3.0	2.6	3.4	6.8	6.0	12.8	34.2	112.0
Firm 19:													
1922.....	0.1	1.4	...	....	8.3	1.1	2.2	2.4	1.9	3.2	2.9	10.3	33.8
1923.....	...	2.1	...	....	17.7	2.4	4.3	5.5	6.8	6.4	5.9	3.3	54.4
1924.....	...	1.3	...	0.6	7.7	1.0	2.2	1.9	2.3	4.9	2.3	7.4	31.6
Firm 21:													
1922.....	...	72.9	0.5	1.5	118.4	0.5	1.2	2.7	5.2	0.8	6.0	4.9	214.6
1923.....	...	66.2	0.4	0.2	94.9	....	2.7	1.3	0.7	....	5.1	10.4	181.9
1924.....	...	11.5	...	0.8	51.7	0.5	2.1	1.6	0.8	1.8	5.2	20.1	96.1

cent or less for this reason. By 1922, one-half of the firms had appreciable figures for employees dissatisfied with wages, though seven firms had less than one per cent for this cause. In 1923 the general tendency was to increase this cause, but three firms that rated very high in 1922 had dropped to more moderate figures by 1923. In 1924 wage causes were lower than in any year except 1921. Further study of the wage subdivision shows that this item increased in all but six firms in 1923. In three of the six, the year 1922

was so extraordinarily high that further increase was unlikely. Though lower than in 1922, the rates of the next year were still high. In 1924 this cause showed a decrease for all firms. With three exceptions, working conditions increased also in 1923, but increased especially at the plants where separations for this cause are normally high. Work elsewhere, related to wage causes, was the largest major cause of resignations and was especially high in 1923, but did not advance relatively as much as wages.

TABLE 13—PROPORTION OF YEARLY SEPARATIONS ACCORDING TO MAJOR REASONS FOR LEAVING, 1921-1924

YEAR	RESIGNATIONS									DISCHARGES		LAY OFFS	TOTAL
	Wages	Working Conditions	Hours	Labor Policy	Work Elsewhere	Community and Family	Personal	Physical	Unknown	Incompe- tency	Disciplinary		
<i>Firm 1:</i>													
1921.....	0.1	3.2	....	....	23.3	7.3	28.0	8.5	0.3	3.6		25.7	100.0
1922.....	0.8	12.1	....	0.1	31.0	5.3	13.8	11.7	0.4	7.9	5.6	11.3	100.0
1923.....	2.3	22.5	0.1	0.2	29.3	4.9	8.8	5.8	1.6	5.0	7.4	12.1	100.0
1924.....	0.4	5.3	....	0.8	28.5	4.8	11.4	6.5	2.1	5.8	10.5	23.9	100.0
<i>Firm 2:</i>													
1921.....	0.5	7.5	0.5	0.5	10.4	12.0	12.8	11.4	9.3	14.8		20.3	100.0
1922.....	0.7	9.5	0.5	1.6	12.7	9.1	12.5	13.0	5.7	4.9	9.8	20.0	100.0
1923.....	0.9	8.9	1.3	0.5	16.9	7.6	16.8	9.5	9.2	7.3	6.9	14.2	100.0
1924.....	0.6	6.9	0.6	1.3	14.7	8.0	14.6	5.6	13.2	11.1	12.0	11.4	100.0
<i>Firm 3:</i>													
1921.....		3.2	....	....	17.4	....	....	0.7	28.4	7.1		43.2	100.0
1922.....		5.5	....	0.8	14.8	5.5	8.6	7.8	16.4	6.3	7.0	27.3	100.0
1923.....		5.1	....	1.0	12.4	7.2	10.8	5.2	21.6	8.8	5.7	22.2	100.0
1924.....		2.9	2.9	....	16.2	2.9	16.2	22.0	7.4	11.8	1.5	16.2	100.0
<i>Firm 4:</i>													
1921.....	1.0	10.4	....	....	18.2	0.3	8.2	13.4	....	11.0		37.5	100.0
1922.....	1.8	22.6	....	....	28.9	3.6	6.5	13.3	8.1	4.9	7.9	2.4	100.0
1923.....	11.2	19.0	....	....	17.4	3.0	9.1	10.4	12.3	2.3	13.0	2.3	100.0
1924.....	4.7	8.8	....	....	11.4	1.6	7.0	9.2	7.7	3.4	11.7	34.5	100.0
<i>Firm 6:</i>													
1921.....	0.7	1.4	....	....	12.3	....	2.7	2.1	....	6.8		74.0	100.0
1922.....			....	3.13	59.42	....	3.13	6.26	3.13	15.63	3.1	6.2	100.0
1923.....	3.9	7.8	....	2.0	43.1	1.0	1.0	1.0	4.9	25.5	9.8	....	100.0
1924.....		4.8	....	2.9	19.2	1.0	4.8	1.9	1.9	18.3	8.7	36.5	100.0
<i>Firm 7:</i>													
1921.....	0.5	0.9	....	....	6.1	0.1	5.3	21.0	....	6.3		59.8	100.0
1922.....	1.3	2.0	....	0.6	15.6	0.4	5.6	39.3	....	1.6	3.0	30.6	100.0
1923.....	2.8	3.1	....	....	15.8	0.5	7.7	13.4	....	2.5	7.1	47.1	100.0
1924.....	0.9	2.5	....	....	17.1	0.2	4.9	9.2	....	1.6	9.6	54.0	100.0
<i>Firm 8:</i>													
1921.....	0.2	2.1	....	0.3	14.6	1.7	1.8	2.9	7.0	12.0		57.4	100.0
1922.....	0.2	5.1	....	0.9	29.2	2.7	1.8	2.6	37.7	8.6	6.8	4.4	100.0
1923.....	1.4	8.9	....	1.5	33.8	4.0	0.5	4.4	27.6	4.2	7.2	6.5	100.0
1924.....	1.2	4.8	....	0.4	19.8	1.0	4.0	2.5	29.7	8.4	10.2	18.0	100.0
<i>Firm 9:</i>													
1922.....	4.0	9.8	0.4	2.3	31.6	1.3	4.0	4.4	7.9	5.2	11.2	17.9	100.0
1923.....	9.0	11.7	0.5	2.9	33.9	1.8	4.3	6.1	9.1	4.1	6.8	9.8	100.0
1924.....	3.2	9.5	1.1	1.3	29.7	0.6	4.6	8.4	3.8	9.1	12.0	16.7	100.0
<i>Firm 10:</i>													
1921.....	9.5	2.0	1.8	4.2	2.7	2.7	1.2	2.0	0.5	4.7		68.7	100.0
1922.....	7.2	10.0	1.1	1.8	19.2	4.1	7.9	7.7	7.0	9.5	16.9	7.6	100.0
1923.....	5.4	19.6	1.2	2.1	19.5	5.0	5.7	4.9	3.2	5.4	20.7	7.3	100.0
1924.....	7.3	4.7	0.4	1.5	16.7	6.9	7.1	6.2	3.9	6.9	16.3	22.1	100.0

TABLE 13—Continued—PROPORTION OF YEARLY SEPARATIONS ACCORDING TO MAJOR REASONS FOR LEAVING, 1921-1924

YEAR	RESIGNATIONS									DISCHARGES		LAY OFFS	TOTAL
	Wages	Working Conditions	Hours	Labor Policy	Work Elsewhere	Community and Family	Personal	Physical	Unknown	Incompe- tency	Disciplinary		
Firm 11:													
1921.....	5.9	4.2	0.9	....	20.6	1.7	7.1	3.4	5.6	10.9	....	39.7	100.0
1922.....	4.8	8.1	0.4	....	36.8	3.3	7.6	3.4	12.3	8.4	....	14.9	100.0
1923.....	8.3	7.0	0.6	0.4	28.6	4.6	10.9	3.4	23.1	12.2	....	0.9	100.0
1924.....	3.9	3.7	0.7	2.2	31.7	3.9	8.7	3.5	11.3	5.2	11.9	13.3	100.0
Firm 12:													
1922.....	3.3	5.0	0.3	1.5	25.7	6.9	6.6	4.4	9.2	6.3	7.5	23.3	100.0
1923.....	1.2	6.4	0.2	2.6	23.5	7.2	8.0	4.5	14.0	6.2	9.1	17.1	100.0
1924.....	0.6	4.9	0.1	2.7	19.5	6.6	8.3	4.2	6.4	7.5	7.9	31.3	100.0
Firm 14:													
1922.....	42.4	11.2	0.2	1.8	21.0	0.8	3.6	1.6	0.8	5.6	6.2	4.8	100.0
1923.....	15.8	22.6	0.9	3.0	26.4	2.7	5.8	1.2	8.7	3.8	4.0	5.1	100.0
1924.....	2.1	4.2	0.5	10.6	16.9	0.5	8.4	2.1	....	4.2	1.6	48.9	100.0
Firm 17:													
1922.....	19.1	13.0	0.5	2.3	12.2	8.4	6.4	4.1	15.1	4.8	7.7	6.4	100.0
1923.....	12.4	8.1	0.3	1.5	16.0	6.0	10.3	7.2	19.3	4.5	11.7	2.7	100.0
1924.....	7.7	6.4	0.6	2.9	20.8	6.4	6.7	10.3	15.1	5.8	11.5	5.8	100.0
Firm 18:													
1922.....	13.6	13.9	....	1.9	23.8	3.1	2.1	4.5	26.5	4.9	4.1	1.6	100.0
1923.....	8.8	15.0	0.2	4.3	27.9	2.1	5.9	2.7	21.5	4.1	5.7	1.8	100.0
1924.....	6.1	7.2	....	3.4	21.7	2.7	2.3	3.1	6.1	5.3	11.5	30.6	100.0
Firm 19:													
1922.....	0.4	4.1	....	....	24.5	3.3	6.5	6.9	5.7	9.4	8.6	30.6	100.0
1923.....	....	3.9	....	....	32.6	4.4	7.9	10.0	12.5	11.8	10.8	6.1	100.0
1924.....	....	4.1	....	1.8	24.5	3.2	6.8	5.9	7.3	15.4	7.3	23.7	100.0
Firm 21:													
1922.....	....	34.0	0.2	0.7	55.2	0.2	0.6	1.3	2.4	0.3	2.8	2.3	100.0
1923.....	....	36.4	0.2	0.1	52.2	....	1.5	0.7	0.4	....	2.8	5.7	100.0
1924.....	....	12.0	....	0.8	53.8	0.6	2.2	1.6	0.8	1.9	5.4	20.9	100.0

WORKING CONDITIONS

The heading summarized "working conditions" comprises all cases of dissatisfaction with the nature of the job or with conditions of work. No distinction has been maintained between dislike of the kind of work and dissatisfaction with working arrangements though analysis of the detailed causes shows that such a distinction is often made by employees. The heading covers not only cases of wet, heavy, dusty or dangerous work, but also

cases of eye strain, machines unadjusted in height and unpleasant odors, or poisonous fumes. More definitely, perhaps, than any other cause, working conditions reflect the general character of the industry. As already stated, in chemical plants or any industry where there are ammonia or gas fumes, wet work, or a high percentage of yard work, terminations tend to be high for working conditions. In 1922 fourteen of the firms had less than 15 per cent of all their separations due to this reason alone with two firms having 22

and 34 per cent respectively. In 1923, ten firms had less than 15 and three more than 20 per cent. By 1924 every firm had less than 15, while nine plants were in the less than 5 per cent group.

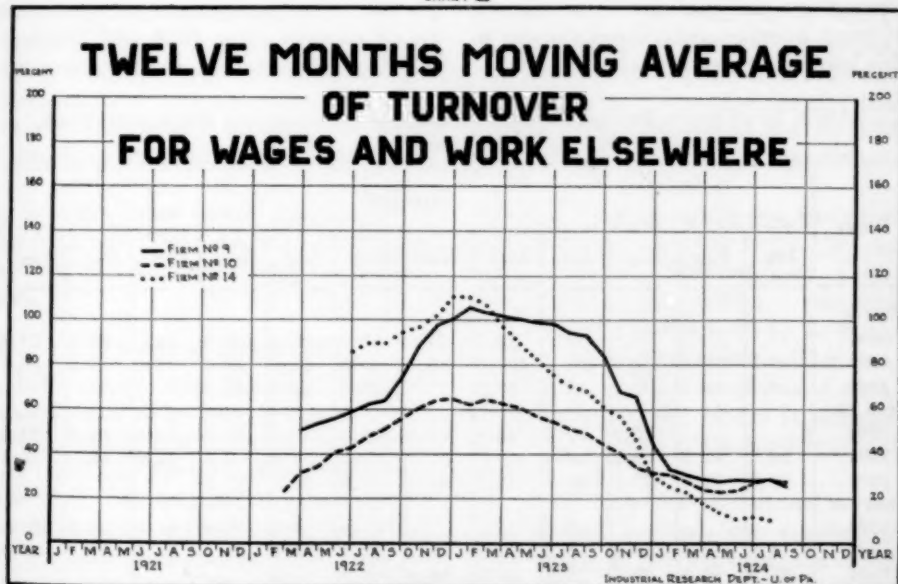
When resignations alone are considered, working conditions accounted for 13.7 per cent in 1922, 16.5 per cent in 1923 and 10.3 per cent in 1924 in all firms considered. These percentages show change in emphasis during the past four years in the importance of working conditions as a cause of change of employment when demand for labor is active enough to permit a choice between jobs. More than half the "separations" in this group are due to dislike of the particular kind of work, often of one specified operation. Others show that employees were too impatient to stay long enough to become acquainted with the firm or processes. Such reasons as "did not think he would like the work," "could not wait to learn," "thought it took too long to learn operation," "did not think he could learn operation,"

"would not repair automatics," show either lack of confidence or childish impatience. These, however, are the exceptions and the reasons are in the main specific objections to noise, oil, heat, odors or heavy work. At one plant with a considerable turnover due to working conditions, 22 per cent of all separations for this cause gave "work too heavy" as a reason for leaving. While odors and fumes cannot be eliminated entirely, it would seem possible to reduce the complaints about heavy work. At any rate, turnover for dissatisfaction with working conditions increases rapidly in periods of active labor demand.

WORK ELSEWHERE

"Work elsewhere" as well as "wages" vary, obviously, according to activity in local plants. The heading covers separations from a plant wherever a definite statement is made that the employee goes to another firm for better pay, or advancement, or is going into business for himself. Among

CHART XI



younger employees are many leaving to return to school, to learn a trade, or to enter classes of any sort. This item, normally the largest single sub-classification of turnover, covers many causes. If as large a proportion of separations as here listed leave with a definite job in mind it would indicate a high degree of forethought on the part of workers. However, pride, reticence and many excuses are doubtless covered by the grouping. Besides, in a period following a depression a high percentage of change is represented by return to a former position or trade. Eight firms in 1922 and nine in 1923 lost more than 25 per cent of all separations for work elsewhere. By 1924 most firms were below 20 per cent and only four above 25 per cent. While active market conditions greatly increase numbers in this group, the response to business conditions seems to be less elastic than is the response of wages.

Turnover for wages and work elsewhere have been combined and moving averages secured for the rate of separations assigned to these causes. Moving average curves are shown on this basis for three firms.

These curves deserve comparison with the moving averages of the same firms for total turnover on Chart IV and for resignations shown on Chart VI. On the total curve, Firm 9 was highest of the three curves, with the top of the bell-shaped moving average curve in February and March, 1923. Firm 10, just below, is high in the same months but a trifle more regular in outline. Firm 14 is far below the other two in the whole rise and fall of three years. In the moving average of resignations the three curves are closer together, the rise and fall more gradual and the likeness of movement very striking.

In the wages and work elsewhere curves, two important causes of resignation are combined. For this grouping the peak of the long period of rising rates seems to be reached about a month earlier than the larger totals, but the curves follow the same general direction though the firms have some reversal in relation to each other, owing to the high proportion of resignations for working conditions at one of these plants. The persistence of the same rising movement in 1922 and the succeeding drop in 1924 in these reasons

TABLE 14—TWELVE MONTHS MOVING AVERAGE OF TURNOVER FOR WAGES AND WORK ELSEWHERE

FIRMS	MONTHS											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Firm 9:</i>												
1922...	.....	.....	.....	50.6	53.4	55.9	58.3	62.3	63.9	74.0	88.3	97.9
1923...	100.8	105.4	103.7	102.2	100.8	99.5	98.5	94.2	93.1	84.0	67.7	56.2
1924...	44.3	33.1	30.8	28.8	28.0	28.7	28.5	28.6	26.6	.....	.....	.....
<i>Firm 10:</i>												
1922...	.....	.....	22.9	31.5	33.8	40.3	42.5	47.6	51.1	55.9	60.3	63.8
1923...	64.2	62.2	64.2	62.6	61.0	57.1	54.9	51.6	49.8	44.9	40.2	34.6
1924...	31.7	31.0	27.7	24.1	23.5	23.8	27.6	28.3	27.3	.....	.....	.....
<i>Firm 14:</i>												
1922...	.....	.....	.....	.....	.....	.....	85.9	89.2	89.2	94.8	97.1	101.9
1923...	110.3	110.1	106.9	96.9	89.2	82.5	75.1	70.4	68.0	61.3	57.0	46.0
1924...	31.5	25.1	22.7	17.7	13.8	10.8	11.1	10.4	.....	.....	.....	.....

pertaining to the job—the causes that should be most dependent upon market adjustments—leads one to claim that some significance attaches to the reasons given by workmen at the time of leaving. The importance of these two reasons may be gauged from the fact that the curves for two of the plants show a rate of about 100 over a period of nearly five months.

COMMUNITY AND FAMILY REASONS

Community and family reasons cover such causes as "leaving to stay at home," "residence too far away from plant," "called away from the city to home on account of illness in family." Women employes leave work to care for members of the family or to meet a family objection to their working, etc. The proportion of community and family reasons remains fairly constant in the same firm from year to year. It is invariably higher in firms employing women than in men's industries. In the table it will be seen that Firms 1, 2, 3, 12 and 17 have higher proportions due to this cause than have other firms that are more particularly men's industries. There is only one case in the four years where more than 10 per cent of separations were occasioned by community and family reasons. In most cases in every year, the bulk of firms have percentages well under five; 1924 is in some cases lower and in others higher than 1923. On the whole the marked constancy in the figures is very striking.

PERSONAL REASONS

Like community reasons, personal reasons tend to be fairly constant within the same firm with one or two exceptions, notably Firm 1 in 1921, and Firm 3 in 1924. Most firms had considerably less than 10 per cent of their separations for reasons classed as personal, though two firms had over 10 per cent in 1922,

4 in 1923 and 3 in 1924. The others were about equally massed in the under-5, and 5-and-under-10 per cent intervals in all years. In the women's industries personal reasons primarily connote marriage. In other industries a few reasons come under wanderlust or the vague term "leaving the city." Some are occasioned by leave of absence, visiting relatives or accompanying a friend or relative. Some of these items are added to by market conditions. "Leaving the city" may often be due to anticipation of a lay off or to accompanying the family because other members have found work elsewhere, consequently the voluntary character of personal reasons should not be overstressed.

PHYSICAL REASONS

No separation of ill health due to factory work from that due to other causes has been possible under physical reasons. In fact, few sub-classifications occur in the reporting except general terms such as sickness, ill, etc. The proportion for physical reasons does not vary considerably from year to year when large groups are considered. In all firms, 5.3 in 1922, 6.3 in 1923 and 5.6 in 1924, were reported for physical reasons. The average of 6.3 in 1923 means a range from 0.7 in one firm to 10.4 per cent in another.

Wages, working conditions, and work elsewhere vary directly with the demand for labor in the market. Community and family reasons, personal and physical reasons tend to be fairly constant from time to time. This conclusion based upon an analysis of separations at individual plants is summarized by combining the annual figures of sixteen firms.

In total amounts, community reasons (when all plants are combined) never reach 4 per cent of the total separations, personal reasons range

TABLE 15—PROPORTION OF SEPARATIONS ACCORDING TO MAJOR REASONS FOR LEAVING
Combined for All Firms

YEAR	RESIGNATIONS									DISCHARGES		LAY OFFS	TOTAL
	Wages	Working Conditions	Hours	Labor Policy	Work Elsewhere	Community and Family	Personal	Physical	Unknown	Incompe- tency	Disciplinary		
1922.....	4.1	10.0	0.2	0.9	25.9	3.8	6.2	5.3	16.0	5.3	6.1	16.2	100.0
1923.....	5.6	12.0	0.3	1.0	23.7	3.8	7.0	6.3	13.2	5.3	8.1	13.7	100.0
1924.....	2.3	5.6	0.2	1.3	20.6	3.3	6.6	5.6	9.0	5.7	10.1	29.7	100.0

from 6.2 to 7 per cent in the three years considered, while physical causes amount to 5.3, 6.3 and 5.6 per cent of the total. If these three reasons dependent upon social and health conditions are combined, one has 15 or 16 per cent of the turnover. More important than the three above items is the proportion due to work elsewhere which includes one-fourth to one-fifth of all separations. Next in importance is working conditions, an item which varies according to the character of the industry and increases rapidly when jobs are plentiful enough to make resignation seem advantageous to employees. The proportions under each major cause as discussed above are based on all separations with discharges and lay offs included.

An arrangement of resignations alone is given for each year, according to the amount of turnover caused by reasons connected with the job and those attributed to health and social factors.

Unfortunately the value of this classification is somewhat lessened by the "unknown" items mainly due to terminations without notice. It would be unlikely that these unknown items would not be in part due to the job. At any rate, there are wide differences in firms in the proportion of resignations attributable to family and social life. In most cases dissatisfaction con-

nected with the job is measurably more important than the combined social causes.

This arrangement of resignations takes no account of the size of the total amounts. The concern is merely with the proportion that each type of causes bears to the other in each year. Fourteen firms in 1922 had higher proportions in reasons connected with the job than in the class called, for brevity, *social reasons*. The same firms were higher, also, in 1923 with a tendency to be markedly higher. In each of three years (1922-24), six firms had 50 to 60 per cent of resignations for reasons connected with the job; six more in two years and seven in the third year were far above 60. For social reasons all firms were below 60 in all years, with twelve, thirteen and nine firms below 30 in the respective years. The proportion of *social reasons* rank higher in 1924 when total turnover was low and there were fewer resignations for reasons connected with the job.

CAUSES OF DISCHARGES

All discharges have been grouped under one of two major classes—i.e. (1) discharges for incompetency, and (2) discharges for disciplinary reasons. The first includes slow or inefficient workers and all cases of inability to do the work. Some are doubtless cases of

poor selection for the job. On skilled jobs some are due to overstatement of experience or overconfidence in skill. In these cases, taking a man at his own value means discharging him later. The second group indicates unsocial or unco-operative qualities. Though some of the small plants may have no discharges for months, neither kind of terminations by discharge is entirely avoidable. Discharges tend to be high when payrolls are expanding. On the other hand, it would be likely for discharge rates to rise in a period of depression since inexperienced workers and infringement of rules would be less leniently dealt with than in rush periods. At the same time there is an opportunity to drop incompetent workers among those laid off, thus tending to confuse and lower discharge figures. When labor is scarce discharges may be delayed as long as possible, but they are not likely to be entirely avoided. In

the period under consideration if new hirings and depression were dominating causes, discharge rates should be low in 1924. On the contrary, despite low turnover in that year, the discharge rates tend to be high. Discharges for disciplinary reasons range much higher than for incompetency. In 1922, only one firm had more than 10 per cent of separations due to incompetence. Three firms in 1923, and four in 1924 were far above 10 per cent, while only four firms had less than 5 per cent as opposed to eight and seven firms with less than 5 per cent in the two previous years.

For disciplinary reasons, the largest number of firms had 5 to 10 per cent of separations, but when 1924 is studied, the increase in discharges brings the largest massing of firms in the 10-and-under-15 per cent class. While both classifications of discharges show an increase then, the greatest advance is in the causes listed under disciplinary reasons.

TABLE 16—PROPORTION OF RESIGNATIONS DUE TO SPECIFIED REASONS, 1921-1924

FIRM	REASONS CONNECTED WITH JOB				REASONS CONNECTED WITH SOCIAL LIFE				REASONS UNKNOWN			
	1921	1922	1923	1924	1921	1922	1923	1924	1921	1922	1923	1924
1.....	37.7	58.6	72.1	58.5	61.9	40.8	25.8	38.0	0.4	0.6	2.1	3.5
2.....	29.8	38.4	40.0	36.9	55.8	53.0	47.2	42.9	14.4	8.6	12.8	20.2
3.....	41.6	35.5	29.2	31.3	1.3	36.9	36.6	58.3	57.1	27.6	34.2	10.4
4.....	57.5	62.9	57.7	49.5	42.5	27.5	27.4	35.3	0.0	9.6	14.9	15.2
6.....	75.0	83.3	87.9	73.6	25.0	12.5	4.5	21.1	0.0	4.2	7.6	5.3
7.....	22.2	30.1	50.1	59.1	15.9	9.4	18.9	14.5	61.9	60.5	31.0	26.4
8.....	56.2	44.3	55.6	41.4	20.9	8.7	10.8	11.8	22.9	47.0	33.6	46.8
9.....	...	73.1	73.2	71.8	...	14.8	15.3	22.1	...	12.1	11.5	6.1
10.....	75.7	59.5	71.8	56.1	22.5	29.8	23.4	36.8	1.8	10.7	4.8	7.1
11.....	64.0	65.4	51.7	60.7	24.8	18.6	21.7	23.1	11.2	16.0	26.6	16.2
12.....	...	56.9	50.2	52.1	...	28.5	29.1	35.8	...	14.6	20.7	12.1
14.....	...	91.8	78.9	75.6	...	7.2	11.1	24.4	...	1.0	10.0	0.0
17.....	...	58.1	47.3	50.0	...	23.3	28.9	30.4	...	18.6	23.8	19.6
18.....	...	59.5	63.6	73.2	...	10.9	12.1	15.2	...	29.6	24.3	11.6
19.....	...	56.3	51.2	56.8	...	32.6	31.3	29.6	...	11.1	17.5	13.6
21.....	...	95.2	97.2	92.8	...	2.2	2.4	6.1	...	2.6	0.4	1.1

Discharge rates have risen from negligible amounts in 1921 to figures of considerable importance. Out of 100 separations only about five were due to discharge. By 1922, twelve out of every hundred terminations were discharges. The 1923 records show this amount raised to fourteen, when the totals of all plants are combined. For 1924 the proportion is still higher, amounting to sixteen out of every 100. As compared with 1921, the later years are high. While firms differ in amounts this tendency to increased proportions of discharges is a return to a situation typical of the pre-war period. The increases of 1922 and 1923 could be explained by the influx of new employes,—that of 1924 was provoked by no such additions.

Sufficient attention has been given to lay offs in the discussion of total turnover and main divisions. No accurate separation of lay offs for manufacturing causes by distinction from lay offs due to business conditions has been obtained in reporting.²

² In records of turnover, rates for resignations, discharges and lay offs are as essential as rates for total volume. Some subdivision of resignation and discharge is equally essential. In our subdivisions, demarcation has rarely been possible between dissatisfaction with hours and labor policy and dissatisfaction with working conditions. If these three subclassifications were combined, accuracy would be increased. We are not quite ready to combine wages and work elsewhere, though it is certain that the two frequently overlap. By combining these, the nine classifications under resignations could be reduced to six. We are still convinced that the continuance of at least six subdivisions of resignations is necessary for explanation of totals.

CHAPTER V

LENGTH OF SERVICE

When working forces are being built up some changes occur among new employees in every organization. Some of these changes are a normal part of the adjustment necessary for workers to find a satisfactory working opportunity. When, however, the percentage of employees leaving in the first months becomes great, it should indicate a problem concerned either with methods of introducing or training new workers. If, despite favorable working conditions and adequate training, a high rate of separations continues, then one must question the selection for the jobs or the rate of pay on these jobs.

What constitutes a high rate of change among short service employees is not easy to determine for plants in general. If a firm has been operating for some time without variation in its numbers on the roll, the force, and consequently the separations, will tend to be made up of fairly long service employees, even though the loss of employees is absolutely very low. For instance, in the tables presented for length of service, Firm 1 in 1921 lost about 45 per cent among employees of more than three years' continuous service. In that year this firm had the lowest annual turnover of any reporting firm, i.e. 22 per cent. In other words, the length of service must be studied in terms of production conditions. A long established firm will differ from newer firms in its long service groups or again a plant expanding its operations will tend to have a high percentage of short service employees. The lay offs of a depression such as occurred in 1921 somewhat clear the rolls of short service groups, whereas the building

up of organizations, as in 1922 and early 1923, not only adds the risk of loss of new employees, but changes the whole distribution of length of service in the active force.

To measure turnover definitely in relation to length of service is ordinarily difficult, for it involves a periodic inventory of the length of service of all men on the roll. This is a most difficult record to keep continuously up to date, and such analysis can rarely be made. It is not so difficult to tabulate the length of service of separations and compare resignations, discharges and lay offs. However, short service may be regarded as a *cause* of high turnover, and the cost of depression due to this cause may carry far over into a period of business activity.

The significance of new employees in causing turnover may be illustrated by combining the figures for all firms. In 1922, 64 per cent of all separations are found to have been less than three months at any one plant and 85 per cent less than a year. In 1923, a trifle over 86 per cent were in the less-than-one-year group and 63 per cent in the less-than-three-months. In other words, no difference was evident in the experience of the two years for these intervals. However, the less-than-one-week period with about one-seventh of all separations in 1922 had less than one-tenth in 1923, and about one-twentieth in 1924. During the continuance of mild depression in 1924, when few accessions occurred, the proportions leaving with short service decreased. In this year intervals under the three months had barely 48 per cent, and the less-than-one-year

TABLE 17—PROPORTION OF SEPARATIONS BY LENGTH OF SERVICE AND MAIN DIVISIONS OF TURNOVER
All Firms Combined, 1922-1924

LENGTH OF SERVICE	1922				1923				1924			
	Total	Resig- nation	Dis- charge	Lay Off	Total	Resig- nation	Dis- charge	Lay Off	Total	Resig- nation	Dis- charge	Lay Off
Under 1 week.....	15.5	13.6	1.4	0.5	9.2	7.9	1.0	0.3	5.4	3.9	0.9	0.6
1 week and under 1 mo.	26.5	18.1	3.3	5.1	29.0	18.3	3.7	7.0	19.9	9.8	3.2	6.9
1 mo. and under 3 mos.	21.7	15.4	3.2	3.1	24.3	15.5	3.3	5.5	22.6	11.2	3.2	8.2
3 mos. and under 6 mos.	11.7	8.2	1.8	1.7	13.5	9.1	1.9	2.5	14.5	8.3	2.3	3.9
6 mos. and under 1 yr.	10.0	7.4	1.4	1.2	9.9	6.7	1.6	1.6	14.7	8.1	2.6	4.0
1 yr. and under 2 yrs.	8.5	6.3	1.4	0.8	5.0	3.6	0.7	0.7	11.6	6.7	2.3	2.6
2 yrs. and under 3 yrs.	2.4	1.8	0.3	0.3	3.4	2.6	0.5	0.3	3.3	2.2	0.6	0.5
3 yrs. and under 4 yrs.	1.2	0.9	0.2	0.1	1.6	1.2	0.2	0.2	2.4	1.8	0.4	0.2
4 yrs. and under 5 yrs.	0.9	0.6	0.1	0.2	1.3	0.9	0.1	0.3	1.4	1.0	0.2	0.2
5 yrs. and under 10 yrs.	0.9	0.7	0.1	0.1	1.6	1.2	0.1	0.3	2.5	1.7	0.3	0.5
10 yrs. and under 15 yrs.	0.3	0.3	....	....	0.5	0.4	....	0.1	0.6	0.4	0.1	0.1
15 yrs. and under 20 yrs.	0.2	0.1	0.1	....	0.2	0.2	....	....	0.4	0.2	0.1	0.1
20 yrs. and over.....	0.1	0.1	....	....	0.2	0.2	....	....	0.3	0.2	....	0.1
Unknown.....	0.1	0.1	....	....	0.3	0.2	....	0.1	0.4	0.2	0.1	0.1
Total.....	100.0	73.6	13.2	13.1	100.0	68.0	13.1	18.9	100.0	55.7	16.3	28.0

period 77 per cent. The combined figures in Table 17 cover the same firms in each year.

There is not much to be said for the combination of the figures of all firms in this way. The varying conditions can more adequately be seen by considering the range of differences between firms in a given length of service period. The following table shows the proportion of turnover due to resignations of employes with less than three months' record in any one firm (Table 18).

In 1922, when new hirings were frequent, seven firms showed more than 50 per cent of all resignations among employes on the rolls less than three months. There was a shift to smaller proportions of short service in the separations of 1923 and by 1924 only one firm lost more than 50 per cent in the first three months.

Table 19 gives by firms the percentages of separations accumulated according to length of service. The significant differences occur in the less-than-one-year intervals. Whenever firms are expanding the proportion of short service employes becomes high. The danger of loss in the first months of employment is evident from the fact that, in 1923, the firm with the most favorable experience lost one-sixth of all separations and four firms more than one-half among the groups employed less than one month. In the next year six firms lost less than one-sixth and only two firms as high a proportion as in the previous year during the first month on the rolls. Despite this improvement in 1924, it is certain that whatever the cost of labor turnover, the problem centres about the loss of employes in the first weeks spent with a new concern.

The cross-hatched chart (p. 58) shows the proportion of separations occurring in each year (1922-24) in the first three

TABLE 18

YEAR	PROPORTION OF SEPARATIONS DUE TO RESIGNATIONS															TOTAL
	10-15*	15-20	20-25	25-30	30-35	35-40	Number of Firms					65-70	70-75	75-80	80-85	
							40-45	45-50	50-55	55-60	60-65					
1922.....	..	3	..	1	2	1	..	..	3	1	1	..	..	1	1	14
1923.....	..	..	..	2	1	3	1	2	1	..	2	..	..	1	1	14
1924.....	2	4	2	1	1	..	2	1	1	..	..	..	..	..	..	14

* 10-15 equivalent of 10 and under 15.

TABLE 19.—PROPORTION OF YEARLY SEPARATIONS ACCUMULATED ACCORDING TO LENGTH OF SERVICE, 1921-1924

LENGTH OF SERVICE	FIRM NUMBER											
	Firm 1				Firm 2				Firm 3		Firm 6	
	1921	1922	1923	1924	1921	1922	1923	1924	1922*	1923	1921	1922
Less than 1 week.....	0.4	....	0.4	....	8.9	6.9	7.1	5.2	10.9	2.6	0.0	6.2
" 1 mo.....	4.0	19.9	28.0	6.2	23.0	18.7	21.6	16.5	30.0	16.0	5.5	12.4
" 3 mos.....	9.7	41.6	54.1	20.9	40.4	38.4	38.8	27.6	53.6	37.7	8.9	28.1
" 6 mos.....	14.9	50.9	72.6	31.5	50.1	54.2	50.3	36.5	69.0	51.1	13.0	28.1
" 1 yr.....	24.3	58.1	85.5	49.2	62.0	73.4	63.5	54.8	65.5	72.7	50.7	37.5
" 2 yrs.....	46.3	63.2	88.9	73.9	75.2	85.3	78.6	69.8	73.7	77.9	78.8	43.7
" 3 yrs.....	55.5	74.7	90.4	77.9	81.1	91.4	85.9	78.8	81.9	82.0	87.7	71.9
" 4 yrs.....	68.8	79.7	92.7	80.2	84.0	95.7	90.6	84.5	88.3	90.3	91.1	81.3
" 5 yrs.....	74.4	86.9	94.1	84.7	85.3	96.8	93.5	88.3	92.8	93.9	93.8	90.7
" 10 yrs.....	84.5	93.2	97.3	94.0	86.4	98.1	95.9	92.7	96.4	98.0	98.6	96.9
" 15 yrs.....	91.3	97.0	98.4	96.2	86.8	98.5	96.4	94.2	97.3	98.0	99.3	100.0
" 20 yrs.....	96.1	98.5	99.3	98.6	87.3	98.7	96.5	94.5	99.1	98.5	100.0	....
20 yrs. and over.....	3.7	1.5	0.6	1.4	0.5	0.5	0.3	0.9	....	1.0	....	....
Unknown.....	0.2	....	0.1	....	12.2	0.8	3.2	4.6	0.9	0.5	....	....

* Eleven months only.

TABLE 19—Continued—PROPORTION OF YEARLY SEPARATIONS ACCUMULATED ACCORDING TO LENGTH OF SERVICE, 1921-1924

LENGTH OF SERVICE	FIRM NUMBER											
	Firm 12			Firm 14			Firm 15			Firm 16		
	1922	1923	1924	1922	1923	1924	1921	1922	1923*	1922	1923	1924
Less than 1 week.....	8.1	5.6	3.1	10.2	19.5	2.1	7.7	23.8	24.6	10.2	4.1	0.3
" " 1 mo.....	37.1	31.6	29.7	49.6	56.6	19.0	18.2	53.7	53.1	31.9	20.7	4.5
" " 3 mos.....	58.2	57.6	54.8	78.0	78.8	43.7	41.2	78.5	76.9	59.6	54.8	34.9
" " 6 mos.....	70.8	72.6	67.2	87.2	88.1	56.9	49.6	87.8	86.1	79.8	74.0	67.4
" " 1 yr.....	81.7	84.4	77.6	92.0	94.0	75.3	65.0	92.9	92.0	91.5	88.9	86.3
" " 2 yrs.....	98.8	91.7	90.1	93.8	97.6	88.5	83.2	95.4	95.7	94.4	94.1	91.9
" " 3 yrs.....	99.8	98.9	94.4	96.4	98.0	93.8	88.1	97.1	96.4	96.0	96.9	96.1
" " 4 yrs.....	99.8	99.4	99.2	97.4	98.6	93.8	93.7	97.9	97.4	96.4	98.1	97.9
" " 5 yrs.....	99.8	99.5	99.6	98.2	98.9	96.4	93.1	98.6	98.3	98.0	98.3	98.6
" " 10 yrs.....	99.9	99.7	99.8	99.4	99.4	99.0	100.0	99.8	99.8	....	99.0	99.7
" " 15 yrs.....	100.0	99.8	99.9	99.6	99.9	99.5	....	100.0	....	....	99.5	99.7
" " 20 yrs.....	....	99.8	100.0	99.8	....	99.5	....	....	....	....	100.0	100.0
20 yrs. and over.....	....	0.1	....	....	....	0.5	....	....	0.2	....	....	....
Unknown.....	....	0.1	....	0.2	0.1	....	....	....	....	2.0	....	....
												0.3
											

* Seven months only.

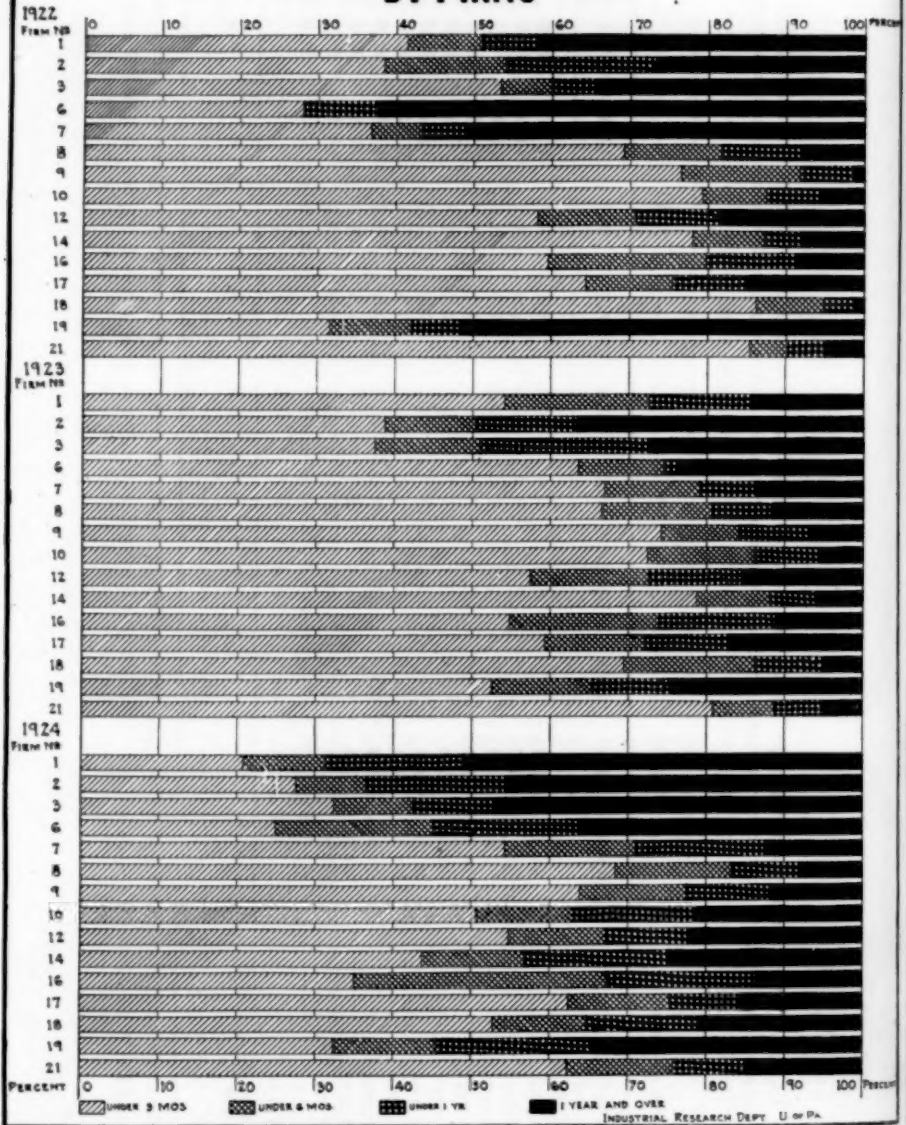
TABLE 19—Continued—PROPORTION OF YEARLY SEPARATIONS ACCUMULATED ACCORDING TO LENGTH OF SERVICE, 1921-1924

LENGTH OF SERVICE	FIRM NUMBER											
	Firm 18			Firm 19			Firm 21			Firm 24		
	1922	1923	1924	1922	1923	1924	1922	1923	1924	1921	1922	1923*
Less than 1 week.....	23.8	14.5	13.8	4.5	7.4	2.3	48.5	38.7	15.7	22.6	24.4	25.1
" 1 mo.....	64.1	49.0	29.8	17.6	23.9	16.4	71.9	64.2	41.5	50.9	44.1	41.2
" 3 mos.....	86.2	69.6	52.7	31.5	52.4	32.3	85.3	80.8	62.2	76.1	62.4	59.7
" 6 mos.....	94.9	86.1	64.9	42.1	65.4	45.5	90.2	88.7	75.8	88.3	73.6	74.9
" 1 yr.....	99.0	95.2	79.4	48.2	75.7	65.5	95.3	94.8	85.3	93.9	89.3	87.4
" 2 yrs.....	99.6	99.1	92.4	64.5	78.9	78.7	97.2	96.0	93.2	96.5	96.4	93.4
" 3 yrs.....	99.8	99.1	98.5	77.2	84.8	83.2	98.9	97.8	95.4	97.2	97.9	97.9
" 4 yrs.....	99.8	99.2	99.6	84.5	89.5	85.9	99.4	98.6	97.3	97.8	98.8	98.5
" 5 yrs.....	99.8	99.4	99.6	89.4	92.7	88.6	99.5	99.3	97.8	98.3	99.5	99.4
" 10 yrs.....	100.0	99.8	100.0	95.1	97.8	95.4	99.9	99.7	99.7	99.5	99.8	100.0
" 15 yrs.....	....	100.0	....	95.5	98.3	97.7	....	100.0	....	99.9	99.9	....
" 20 yrs.....	....	....	....	98.4	99.3	99.1	....	....	....	....	100.0	....
20 yrs. and over.....	....	....	....	1.6	0.7	0.9	0.1	....	0.3	0.1	....	....
Unknown.....	....	....	....	....	....	....	....	....	....	....	....	....

* Seven months only.

CHART III

PROPORTION OF SEPARATIONS BY LENGTH OF SERVICE BY FIRMS



months of employment by contrast with that in other intervals. All terminations with a record of a year or longer in one plant are shown at the end of the bar. The light areas at the left of the bars show the proportion of workers leaving in the first three months of employment. The extent of these areas gives the importance of newly-hired employees in causing turnover; the shift in extent from year to year shows the fluctuating character of production. Eight of the firms lost their highest proportions of short service employees in 1922; four were highest in 1923. Three were about equal in proportions lost in the two years. With the low turnover of 1924 the under-three-months areas lessen. Most plants experienced this decrease and twelve firms have smaller proportions in the under-three-months groups in this year than in either of the preceding years. There is no corresponding shift in proportions from year to year in the three-and-under-six-months sections of the bars—the second cross-hatched area of the chart. For five firms the proportionate loss in this interval was greatest in 1923, in five others in 1924. In the case of four firms the lengths of these sections are nearly identical in all years. This leaves two firms with their highest proportionate loss in 1922 in this interval. The third area represents a period as long as that covered by the two first divisions and is indicative of a marked slowing down in monthly losses. The black areas covering separated employees with one or more years of service decreased in 1923 over 1922 in most cases and lengthened considerably in 1924.

The chart emphasizes the preponderating share of separations for which newly-hired employees are responsible, as well as the variation in turnover distribution in length of service groups at the various plants. However, this distribution in length of service of sepa-

rated employees is not an index of the distribution of service between separated and active employees.

Since the retention of new employees is the critical problem in controlling labor turnover, it would be well to deal with the experience of firms in periods shorter than a year. A frequency grouping by quarters relates the length of service to operation; the first half of the table shows the number of firms with the percentage of employees separating with less than three months of service. For instance, in the first quarter of 1922, before firms began to expand their payrolls, eight firms lost less than 40 per cent among employees of less than three months; by the third quarter there was one firm in the under-40 intervals and all other firms were losing 50 to 90 per cent of all separations in the under-three-months period. As in 1921, the rolls were cleared in the last half of 1923 though less drastically and the figures again shift to lower percentages for the short service groups. In the fourth quarter of 1922, one-half the firms lost 75 per cent of all separations among employees less than three months on the rolls; a year later, only one firm was above 75 per cent in this length of service period.

If one lengthens the period considered and bases the analysis upon the under-one-year group the same sloping off in 1923 and 1924 occurs, but the change is less extreme. The middle quarters of 1923 mark more definitely than other quarters a tendency to concentration of turnover among short service employees. Must this loss in the building up of an organization be regarded as a regular and normal expense of doing business? If so, recruiting must be most expensive in periods when firms are competing keenly for new business. To be sure, this is the period when wages lag farthest behind prices and business activity indicators. Is this

TABLE 20—FREQUENCY OF NUMBER OF FIRMS BY QUARTERS SHOWING PROPORTION OF SEPARATIONS, 1922-1924

PROPORTION OF SEPARATIONS	1922				1923				1924			
	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.
	Less Than Three Months of Service											
Under 5 per cent.	1	1	..	..	..	..	..	..	..	1	1	..
5 and under 10	1	..	..	..	..	..	..	1	..	..	..	..
10 "	1	..	..	..	..	..	..	..	2	..	1	..
15 "	..	..	..	..	..	..	..	..	..	1	..	1
20 "	..	1	..	1	..	..	..	..	1	3	..	..
25 "	1	1	..	..	..	..	..	..	1	..	..	1
30 "	1	1	..	..	..	..	..	..	1	..	1	2
35 "	1	..	1	1	1	1	1	1	2	3	1	..
40 "	3	3	1	..	1	2	3	..	..	1	2	1
45 "	..	..	..	..	..	..	..	3	..	..	2	..
50 "	..	..	..	..	..	..	..	..	2	..	2	1
55 "	1	1	2	1	4	4	..	1	2	3	2	1
60 "	2	2	2	1	2	2	2	3	1	1	1	..
65 "	1	2	3	1	2	2	1	1	3	..	..	1
70 "	..	..	2	1	..	1	1	1	..	1	1	2
75 "	..	..	..	1	3	1	4	3	1	1	2	3
80 "	1	1	..	1	1	2	1	1	..	..	1	..
85 "	..	2	1	3	..	2	1	..	..	..	..	..
90 "	1	1	2	3	1	1	1	..	..	..	..	..
95 "	..	1	1	..	..	..	..	..	..	..	..	..
100	..	..	..	..	..	..	..	..	..	..	..	..
Total Number of Firms	14	14	14	14	15	15	15	15	15	15	15	15

[illegible]

TABLE 21.—FREQUENCY OF NUMBER OF FIRMS BY QUARTERS SHOWING PROPORTION OF RESIGNATIONS, 1922-1924

PROPORTION OF RESIGNATIONS	1922				1923				1924			
	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.
	Less Than Three Months Service											
	Number of Firms											
0 per cent.....	1	1	1	1	1	1	1	1	1	1	1	1
Under 5.....	1	1	1	1	1	1	1	1	1	1	1	1
5 and under 10.....	1	1	1	1	1	1	1	1	1	1	1	1
10 ".....	1	1	1	1	1	1	1	1	1	1	1	1
15 ".....	1	1	1	1	1	1	1	1	1	1	1	1
20 ".....	1	1	1	1	1	1	1	1	1	1	1	1
25 ".....	1	1	1	1	1	1	1	1	1	1	1	1
30 ".....	1	1	1	1	1	1	1	1	1	1	1	1
35 ".....	1	1	1	1	1	1	1	1	1	1	1	1
40 ".....	1	1	1	1	1	1	1	1	1	1	1	1
45 ".....	1	1	1	1	1	1	1	1	1	1	1	1
50 ".....	1	1	1	1	1	1	1	1	1	1	1	1
55 ".....	1	1	1	1	1	1	1	1	1	1	1	1
60 ".....	1	1	1	1	1	1	1	1	1	1	1	1
65 ".....	1	1	1	1	1	1	1	1	1	1	1	1
70 ".....	1	1	1	1	1	1	1	1	1	1	1	1
75 ".....	1	1	1	1	1	1	1	1	1	1	1	1
80 ".....	1	1	1	1	1	1	1	1	1	1	1	1
85 ".....	1	1	1	1	1	1	1	1	1	1	1	1
90 ".....	1	1	1	1	1	1	1	1	1	1	1	1
95 ".....	1	1	1	1	1	1	1	1	1	1	1	1
100 ".....	1	1	1	1	1	1	1	1	1	1	1	1
Total Number of Firms.....	14	14	14	14	15	15	15	15	15	15	15	15

lag reflected most in entrance rates? Are employees shopping for better rates, or better jobs, or more satisfactory surroundings? Or is the whole problem one of selection and training? Certainly in this item the cost of industrial depression carries far over into a period of prosperity.

The necessity for discharging incompetent employees cannot be regarded as a sufficient explanation of the figures. The problem is mainly one of voluntary leaving and the frequency tables for resignations following, show as extreme shifts from quarter to quarter as were found in the total figures. From the beginning of the third quarter of 1922 to the end of the second quarter of 1923, the firms tend to be massed in the high percentage intervals. Four firms in the third quarter of 1922 had 60 per cent or over of all turnover caused by resignations of employees of less than three months' service. In the fourth quarter seven firms were above 60. By the fourth quarter of 1923 there was no firm in intervals above 55—a situation that persisted with one exception until the last quarter of 1924. In other words, the quarters of highest losses in short service groups were those in which business was most active. A change to a high percentage of short service employees is as characteristic of resignations as of total turnover and may be said to be extreme in periods of expanding payrolls. These wide variations in the extent of time employees remained at any one plant give some important facts in connection with labor stability.

Not only is there much variation between different companies but there is wide variation between different periods for the same company. As will appear later, there is a similar deviation between different jobs even if the same company and period are considered. Yet this type of analysis must be under-

stood to reflect only the plant situation so far as employees leaving are concerned. It would be easy to misinterpret length of service figures by failing to take into account the continuity of employment among those who remain at work.

The numbers in each sub-classification are large enough in one firm to warrant separate analysis. The effect of the extreme adjustments of the period is evident from the sweeping changes from year to year in the proportions of employees leaving the plant with less than one month of service. Less than one twenty-fifth were in this interval in 1921, about one-fifth in 1922 and 1924, and two-fifths in 1923. In the under-three-months intervals the 12 per cent of 1921 reached 36, 67 and 54 per cent in the following years. The separations of 1922 then had shorter length of service records than those of 1921, while those of 1923 were considerably shorter than 1922. The change in length of service may be stressed by comparing the proportion of annual separations with one or more years of service. The 53.5 per cent in 1921 and 51.8 per cent in 1922 are represented by only 13.5 in the 1923 figure, and 12.4 in those of 1924. While less than half the separations in the first two years had not been with the company one year, by 1923 only about one-eighth had stayed for a year, and two-thirds had less than three months' experience with the company.

Up to this point length of service has been considered without regard to causes for turnover. It must be remembered that lay offs were highest in 1921 and 1924, resignations in 1922 and 1923.

Distribution of the separations according to main divisions and length of service shows that the longest service groups are among the resignations. Except in 1921, discharges among

TABLE 22—PROPORTION OF SEPARATIONS BY LENGTH OF SERVICE AND MAIN DIVISIONS OF TURNOVER AT ONE LARGE CONCERN, 1921-1924

LENGTH OF SERVICE	1921				1922				1923				1924			
	Total	Resig- nation	Dis- charge	Lay Off	Total	Resig- nation	Dis- charge	Lay Off	Total	Resig- nation	Dis- charge	Lay Off	Total	Resig- nation	Dis- charge	Lay Off
Under 1 week.....	0.5	0.3	0.1	0.1	1.4	0.9	0.4	0.1	3.5	1.6	1.1	0.8	2.3	1.2	0.7	0.4
1 week and under 1 mo..	3.3	2.0	0.8	0.5	18.7	9.2	1.6	7.9	36.5	13.5	3.9	19.1	21.6	6.2	3.3	12.1
1 mo. " " 3 mos.	8.3	3.8	1.3	3.2	15.4	10.0	1.1	4.3	26.9	11.7	2.5	12.7	30.3	10.5	3.0	16.8
3 mos. " " 6 mos.	13.3	5.3	1.2	6.8	7.1	5.4	0.2	1.5	12.3	5.6	1.1	5.6	16.8	5.9	1.7	9.2
6 mos. " " 1 yr.	20.9	6.8	1.2	12.9	5.6	4.0	0.2	1.4	7.3	3.1	0.5	3.7	16.5	5.2	1.5	9.8
1 yr. " " 2 yrs.	19.4	5.6	0.7	13.1	14.1	9.6	0.2	4.3	2.1	1.2	0.1	0.8	6.2	2.4	0.6	3.2
2 yrs. " " 3 yrs.	15.3	4.5	0.5	10.3	9.4	5.8	0.3	3.3	2.05	1.2	0.05	0.8	1.3	0.6	0.1	0.6
3 yrs. " " 4 yrs.	15.5	4.4	0.4	10.7	9.4	5.8	0.2	3.4	1.75	1.0	0.05	0.7	0.5	0.2	0.1	0.2
4 yrs. " " 5 yrs.	...	...	...	...	9.7	7.3	0.2	2.2	2.9	1.7	0.1	1.1	0.7	0.4	0.1	0.2
5 yrs. " " 10 yrs.	3.3	1.1	0.1	2.1	9.2	6.8	0.2	2.2	3.2	1.9	0.1	1.2	2.8	1.6	0.1	1.1
10 yrs. " " 15 yrs.	...	...	...	...	...	...	...	...	0.75	0.4	0.05	0.3	0.4	0.3	...	0.1
15 yrs. " " 20 yrs.	...	...	...	...	...	...	...	...	0.25	0.1	0.05	0.1	0.2	0.1	...	0.1
20 yrs. and over.....	...	...	...	...	...	...	...	...	0.5	0.3	...	0.2	0.3	0.1	...	0.2
Unknown.....	0.2	0.1	...	0.1	...	...	...	...	...	...	...	...	0.1	0.1	...	...
Total.....	100.0	33.9	6.3	59.8	100.0	64.8	4.6	30.6	100.0	43.3	9.6	47.1	100.0	34.8	11.2	54.0

employees of a year or more of service amount to only about 1 per cent of all separations. In the drastic reductions of 1921, lay offs in the one-year-and-over group were 36 per cent of all separations, discharges 1.7 per cent and resignations 16 per cent. In 1922 in this group, lay offs constituted 15 per cent, discharges 1 per cent, and resignations 35.3 per cent. The sweeping change of the next year concentrates the turnover in the short service intervals. Of all separations, the group with one year or more of service has 5 per cent for lay offs, one-half of 1 per cent for discharges, and 8 per cent for resignations.

Separations ratios should be considered in the light of the length of service of active employees. An audit at the end of 1922 shows that 21 per cent of the payroll in this firm had less than three months' service. If one may assume that this ratio maintained through the year, 36 per cent of the separations were due to this 21 per cent of the force. Or to take a longer interval, the 35 per cent with less than one year of service caused 52 per cent of the turnover. The heaviest loss of employees with more than a year of service in any of the four years was in 1922 in the one-to-two-year group. By contrast with these groups were 36.4 per cent of the active roll with five or more years

of experience contributing only 9.2 per cent of the total separations.

The results of audits in each year show the following percentages (Table 23 below) among employees on the active roll.

The entrances in the second quarter of 1923 increased the under-three-months group and raised the proportion with less than one year of service from 35.1 per cent at the end of 1922 to 40.9 per cent at the end of May, 1923. The loss of employees with one to four years of service was considerably greater in 1922 and less in 1923 than the proportion of that length of experience in the active force; the loss of short service employees was markedly greater.

One may conclude that in 1923 the plant was losing a larger proportion of employees of less than one year of service than in previous years and that this proportion of separations represents more than twice the proportion of the working force employed the same length of time. Despite the fact that more than one-third of the working force have five or more years of service, the separations in this group constitute only a trifle over 9 per cent of all separations in the year of greatest loss of experienced workers and was not over 4 per cent in more moderate years of turnover.

TABLE 23

LENGTH OF SERVICE	END OF 1922	MIDDLE OF 1923	END OF 1924
Under 1 week	1.7	2.2	1.9
1 week and under 1 mo.	5.0	9.2	6.0
1 mo. " " 3 mos.	14.1	13.7	8.5
3 mos. " " 6 mos.	5.1	6.1	6.7
6 mos. " " 1 yr.	9.2	9.7	8.0
1 yr. " " 2 yrs.	1.9	5.2	20.2
2 yrs. " " 3 yrs.	7.3	4.6	9.2
3 yrs. " " 4 yrs.	7.3	4.5	0.9
4 yrs. " " 5 yrs.	12.0	7.1	3.4
5 yrs. and over	36.4	37.7	35.2

In the active force, from 59 to 69 per cent of the number employed in each year had been in continuous service for one year or more. Obviously these employees contributed in no way to the labor turnover of the year. Seventeen per cent have ten or more years of continuous record with the company showing a nucleus of very long service employees. If the turnover were computed for the groups under one year, an annual figure of 171 per cent would be found in 1922 against 12 per cent for loss among all employees of one year or more service. The differences in the 1924 rates would be still more extreme. Employees under one year had a turnover rate of 203, while those over a year reached a trifle over 13 per cent.

No different conclusions are reached if other firms are considered.

Table 24 shows for four firms the proportion in the active force and the proportion of separations grouped according to length of service. More than half the separations at Firm K oc-

curred among under-one-year groups, though such groups only comprised 15 per cent of the total force. At a second firm nearly two-thirds of all separations had less than one year of service though an audit of the roll showed only 8 per cent of the active force in these intervals. At the third firm the divergence is not so great between the separations and the active roll, but even here only 36 per cent of the roll was represented in the under-one-year group, while 88 per cent of the separations were in these intervals. Twenty-five per cent of the employees with more than four years of service at the fourth firm contributed less than one-half of 1 per cent to the separations, while the 10 per cent with more than ten years of service had no separations. Against these is balanced one-fourth of the payroll, contributing 53 per cent of the separations in a length of service interval of less-than-three-months.

The turnover rate for the under-one-year groups was 77, 515, 198 and 166 at the respective firms, that for the one-

TABLE 24—PROPORTION OF SEPARATIONS AND AVERAGE NUMBER ON PAYROLL Accumulated for Four Firms, 1924

LENGTH OF SERVICE	FIRM K		FIRM L		FIRM M		FIRM N	
	Separations	Av. No. on Roll	Separations	Av. No. on Roll	Separations	Av. No. on Roll	Separations	Av. No. on Roll
Less than 1 week .	2.9	....	3.8	....	11.6	3.0	13.8	2.2
" " 1 mo. . .	14.7	1.3	11.5	1.9	39.9	7.2	29.8	16.2
" " 3 mos . .	32.3	5.4	25.0	2.5	63.9	13.0	52.7	26.1
" " 6 mos . .	42.6	13.4	45.2	3.1	77.6	22.8	64.9	35.6
" " 1 yr. . .	52.9	15.0	64.4	8.0	88.4	35.8	79.4	45.9
" " 2 yrs . .	79.4	21.7	75.9	29.6	95.4	55.1	92.4	61.0
" " 3 yrs . .	80.9	36.1	84.6	37.0	97.5	73.6	98.5	74.2
" " 4 yrs . .	83.9	37.0	86.5	38.9	97.9	82.2	99.6	76.8
" " 5 yrs . .	86.8	43.1	88.4	50.6	97.9	84.1	99.6	77.2
" " 10 yrs. .	94.1	64.8	96.1	79.6	98.5	95.6	100.0	88.9
" " 15 yrs. .	95.6	70.6	99.0	93.8	98.7	98.6	....	90.0
" " 20 yrs. .	98.5	76.7	99.0	98.8	98.7	99.8	....	91.5
20 yrs. and over . .	1.5	23.3	1.0	1.2	....	....	....	8.1
Unknown . . . . .	....	....	....	....	1.3	0.2	....	0.4

year-and-over was 12, 25, 15 and 37 respectively.

The presence of a high percentage of relatively permanent employes does not seem to be a factor in helping to adjust new employes. The first firm on Table 24 had 23 per cent of its force with the company twenty years or over and 35 per cent ten years or over. More than half (57 per cent) had continuous records of five years or over. These figures should be stressed, since the analysis of the separations alone is easily misinterpreted to mean that most employes stay a year or less on the same job. The preponderance in separations of short service employes means that the same job is vacated four or five times before a satisfactory balance between the requirements of the work and the worker is made. The second firm on Table 24 had a mere fraction of its employes (1.2 per cent) in the twenty-year-and-over group, but had 20 per cent enrolled for ten or more

years. When the 29 per cent enrolled five to ten years are added to this group, nearly half the organization are found in this company's employ more than five years. The third firm has no similar proportions of long service groups. Less than a sixth have ten-year records. However, this firm does have a high proportion in the middle length of service periods, since one-half of the enrollment have had one to five years' experience with the company. The fourth firm has 8 per cent with twenty years of service, and 11 per cent with more than ten years. One-fourth of the roll have a record of more than five years and 54 per cent more than a year. In all firms here considered the problem of labor turnover is narrowed to little more than one-third of the organization in the most extreme cases.

Further discussion of the influence of nationality and occupation upon length of service will be found in the chapters on these subjects.

CHAPTER VI

TURNOVER IN OCCUPATIONAL GROUPS CLASSIFIED BY GRADES OF SKILL

Owing to the large number of separations in the early months of employment, it could be assumed that all occupations contribute more or less to labor turnover. One is hampered somewhat in further analyzing the separations by the lack of any logical classification of skilled and unskilled occupations. In the metal industry classifications are liable to designate most specialized machine occupations as semi-skilled, reserving the term "skilled" for the older occupations, generally regarded as crafts. These are recognized as the occupations requiring apprenticeship training in a pre-machine era. In the textile industry specialized occupations, such as spinning, quilling and coning, are classed as skilled. In other words, two wholly different bases of classification are found. In the main in the metal industry the more all-round the knowledge and training of a workman, and the greater the variety of situations he can meet, the more likely his work is to be regarded as skilled even though in many special occupations a higher standard of speed and accuracy may be attained on one or more operations by specialized workers. This is doubtless due to the fact that great differences in final operations can be due to early processes. Also to the fact that men who know operations from the raw material to the finished article have great adaptability and have accumulated from observation and training wide knowledge of materials, tools and processes. When one comes to the textile industry with its more standardized raw material, performance on a particular operation rather than broad knowledge of many

operations has greatest value to the industry, and no one hesitates to class coning, quilling or beaming with spinning or weaving as skilled operations. In one textile group, loom-fixers and repairers, the basis of classification seems to depend upon broad knowledge of different operations.

While this basis of classification is recognized as being antiquated, we are forced to follow traditional usage. In tracing the influence upon turnover, occupations have been subdivided into five groups:

- (1) Clerical
- (2) Minor Executive
- (3) Skilled
- (4) Semi-skilled
- (5) Unskilled

There is no standard terminology to assist in placing occupations under these major groups. Representatives of firms have assisted in determining the occupations to be included under each subdivision for their plant, and the grouping is consistent from period to period at the same plant. Between plants comparisons are more unsafe and it is impossible to total items for all plants. Analysis, then, must be made only between the major groups for each plant.

For one large firm occupational audits have been made to secure the number in each group. Quarterly percentages are shown for total turnover among these groups and also a subdivision of the turnover into resignations, discharges and lay offs.

TOTAL TURNOVER BY QUARTERS

Considering the totals for separations it will be seen that unskilled workers show highest turnover in every quarter.

TABLE 25—ANNUAL TURNOVER RATES BY QUARTERS

OCCUPATIONAL GROUP	1923				1924			
	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.
Clerical.....	66.1	83.5	28.6	38.6	23.3	19.2	19.0	15.9
Minor Executive.....	25.5	21.5	26.1	22.2	12.0	15.6	7.0	5.2
Skilled A.....	60.7	81.4	68.3	77.9	43.5	49.1	19.9	20.4
Skilled B.....	212.5	156.1	138.6	88.1	97.1	108.2	111.9	81.6
All Skilled.....	99.5	98.9	84.5	80.1	55.3	61.8	38.9	32.7
Semi-skilled.....	90.8	176.6	124.6	87.0	79.7	90.9	52.2	32.6
Unskilled.....	233.6	310.9	339.8	254.7	225.3	197.5	121.3	85.5
Total.....	129.9	170.7	161.3	124.1	103.5	101.6	60.4	42.1

With the exception of two quarters where differences are slight, the semi-skilled are higher than all skilled. Within the skilled occupations there is so much variation among different groups that a subdivision was made into "Skilled A," an item made up of recognized trades found in many industries, such as blacksmiths, carpenters, electricians, etc., and "Skilled B," comprising occupations peculiar to this type of manufacture.

In every case, the turnover is lower for skilled occupations in the A group than for those in the B group. Besides, the skilled A occupations normally show less extreme fluctuations of turnover than the skilled B group. The continued and clear-marked difference between the two skilled groups points to the need of further analysis of skilled occupations and probably explains some of the conflicts in the findings of various currently quoted research studies. Most research students agree in attributing a high rate of turnover to unskilled workers. There is no such general agreement concerning the relative stability of skilled and semi-skilled.

It is at this point that classification is most defective. All firms agree in

grouping toolmakers, general machinists, electricians, pattern makers, etc., in the skilled A occupations. When one comes to the occupations peculiar to a particular type of manufacture, the rating must be based on the value of the operation in relation to others in the plant. Such an occupation as grinding will be valued by one plant as skilled, by another as semi-skilled, or grinding processes may even be split between the two groups, those on one type of machine being ranked as highly skilled, while others stand far down in the semi-skilled grades. If one is interested in the relationship between skill and stability, the inclusion of all skilled occupations gives a group too heterogeneous to warrant uniformity of conclusions.

OPINIONS OF EXPERT TOOLMAKERS ON VALUE OF CHANGING JOBS

Within the highly skilled trades it is probably true that some of the skilled men have a very high turnover in the first ten or fifteen years following apprenticeship. This would occur whenever it is necessary for workmen to meet emergency conditions in their trade. In a study of Philadelphia toolmakers, based on the histories of

workmen, the Industrial Research Department has found not only a large number of changes on the part of expert workmen, but a consistent reiteration of the belief that such changes were essential in developing the highest degree of skill. Though these statements will be given in the "Toolmakers Study," they are of such significance in explaining the purpose of changes in employment by skilled workmen, that comment on this point is quoted. One toolmaker writes:

It is obvious to me that an apprentice on completing his time should change his job, if he feels that he is capable and has acquired a general knowledge of the work in his first shop. General machinist and tool and die work cover a very large field. No mechanic after his apprenticeship is a first-class machinist, tool or diemaker. After I had served my apprenticeship I was considered a first-class tool and diemaker, I had made every kind of tool used in the manufacture of —, 20 per cent of the tools were dies. These dies were different in general construction from those used in most shops. There was not much general tool work to be done, such as jigs, fixtures, reamers, etc., few shops need every kind of tool—consequently when I made a change I found I was not so good and I was kept busy trying to hold my own.

In most large shops a toolmaker is kept on a particular kind of work which would make him a specialist if he were to stay with a firm too long. Then, there are almost as many ways of doing work as there are shops. I have seen men who were considered good in one shop a failure in another. Some toolmakers are so accustomed to very accurate work that they would be considered slow in most shops; others are good, fast men on work not so particular, but cannot make an accurate gauge or die.

There are two advantages for the man who stays with one firm: he gets so accustomed to their work that it becomes easy; he also receives the highest rate of pay. The man who jumps around does get a greater and broader experience but sac-

rifices the more pay until he puts his greater experience to use.

Another toolmaker writes:

My advice to a boy is to visit different shops, observing closely and conversing with foremen and workmen to obtain some information and advice on their line of work, both heavy and light. . . . The same general advice will apply to toolmaking. Try and obtain a job in some shop where they make a specialty of experimental work . . . or some mathematical instrument shop where he will learn to work close and also learn to design tools for automatic machine work which require a high-class of toolmaking. Move around not so much for the sake of changing, but with a desire to add some special experience along new lines and when he has found a good position settle down and go after the best position in the shop.

This is a new aspect of labor turnover and one that is important for many skilled trades. Another toolmaker writes:

After a man completes his apprenticeship he stands a better chance of becoming a first-class tool and diemaker by working in as many shops as he can for a period of about ten years. . . .

The things that a tool and diemaker will learn in shifting around are many and varied. He will learn different shop practices, and many new ways of doing his work by coming in contact with the methods of different workmen.

The comment of another workman is:

A man going from one shop to another will learn the use of different machines and in less time than in one shop.

A different advantage is stressed by a fifth workman when he writes:

A machinist who goes around from one shop to another not only has the benefit of his own knowledge but has the use of the brains of whoever he works with if he keeps his eyes open. He also is compelled to do work on machines that are not built for the

work whereas, if he is in an up-to-date tool shop, he has all kinds of tools to work with. Take him away from these and he is lost. In other words—a poorly equipped shop trains one to use the machines at hand.

Or, as stated by another workman:

In small poorly equipped shops one learns to be resourceful; in larger shops one often runs into an entirely new machine tool.

Another argument is given for frequent change of employment in the comment that:

A toolmaker should come in contact with production in order to build the best tools, and he can only do so by shifting around a little and working for small as well as large shops. In a small shop that is not fully equipped he learns how to use a machine tool for many different purposes; in a large shop he learns routine of production.

In these comments workmen are not only stressing the advantage of variety of work and the uses of different kinds of equipment, but also, "the contact with so many more men, from whom in many cases one learns new ideas."

Further, men like to work with workmen and foremen who have had varied experiences. One writes:

In my experience of changing from one job to another I have always found that wherever you went you would see how little you know, no matter how much experience you had, for no two shops would work under the same thought. In fact, the manner in which they would do their work would always rest on the foreman. If the foreman had changed jobs much himself, he would give you more leeway, but if the foreman had never made a change you would feel as if you were learning your trade over again, for whatever you would do it would never suit the foreman.

In regard to the men who never change, you will always find them narrow-minded and very jealous of their jobs. They will watch for the least mistake and then stand in groups and talk about it, but in a shop where men have changed a lot, you will find the men cannot do enough for each other in helping a new man to make good. The man who changes jobs is always learning new ideas where the man who never changes will very seldom accept a new idea, fearing it will not be right.

TABLE 26—TURNOVER OF OCCUPATIONAL GROUPS ACCORDING TO MAJOR REASONS FOR LEAVING, 1923-1924

OCCUPATIONAL GROUP	RESIGNATIONS						DIS-CHARGES	LAY OFFS	TOTAL
	Wages	Working Conditions	Work Elsewhere	Community Family and Physical	Unknown	All Resignations			
Skilled A:									
1923.....	1.2	1.4	18.1	7.4	12.1	40.2	3.3	28.9	72.4
1924.....	0.4	0.4	9.6	1.7	4.1	16.2	3.8	12.8	32.8
Skilled B:									
1923.....	5.4	6.3	22.4	12.6	11.6	58.3	22.4	68.6	149.3
1924.....	....	7.0	14.0	8.5	10.5	40.0	13.0	46.5	99.5
Semi-skilled:									
1923.....	4.0	5.0	17.6	9.0	17.6	53.2	11.0	54.8	119.0
1924.....	1.1	1.1	11.9	2.4	7.3	23.8	5.0	35.8	64.6
Unskilled:									
1923.....	8.1	7.8	38.9	22.0	36.4	113.2	29.6	141.9	284.7
1924.....	1.0	4.0	22.1	8.0	12.0	47.1	19.8	94.5	161.4

These comments are very significant and raise many queries concerning the cost and value of labor turnover in skilled trades. However, that is part of another study. They are quoted here to show that conflicting conclusions on the turnover of skilled groups may result from grouping expert jobs in a classification with others less dependent upon wide experience and observation.

Other things being equal, one would expect lower turnover among middle aged and older men than among men in the first decade following training. One would also expect a lower turnover in occupations peculiar to one type of manufacture than to the craft found in many industries. This does not explain the figures here considered for one would have expected the skilled A group to show higher turnover than the B group, and some further analysis is necessary to account for the differences.

MAJOR REASONS FOR LEAVING

The explanation is in part found in the major reasons for leaving in Table 26. For the skilled A group there are few separations definitely laid to wages or working conditions. This means that the wages and kind of work of these occupations tend to be in a measure standardized, whereas there is no similar standardization for the occupations peculiar to a particular type of industry. In the case of wages, skilled occupations peculiar to a particular type of industry are not only those upon which information is scarce, but are the occupations concerning which exchange of information is least willingly made. Besides, the lay offs were especially severe for these occupations, making the positions seem insecure for 1923 and much of 1924. Wage complaints caused a smaller proportion of the turnover among semi-skilled groups in 1923 than among the skilled B employees,

but the considerable numbers who left without giving any reason make conclusions risky.

The percentages of semi-skilled were lower in dissatisfaction with working conditions in both years. In 1924 only 1 per cent were attributed to working conditions against 7.0 per cent in the skilled B group. Work elsewhere, also, was lower for semi-skilled, making all reasons connected with the job, except such as cannot be separated from unknown causes, higher in 1923 for skilled B than for semi-skilled. This distinction would be obscured if all skilled occupations had been combined, since dissatisfaction with wages and working conditions are minor amounts for the skilled A occupations. Skilled B have higher rates also for discharges and lay offs than semi-skilled. Unskilled employees' turnover rates were, roughly speaking, double those of semi-skilled for every major cause except working conditions when the proportions were in the ratio of eight to five in 1923. Unknown items—due to quitting without notice—were higher for unskilled than for the artisan groups.

Ranked according to turnover, the skilled A had the lowest rate, semi-skilled next, skilled B third, with unskilled highest, for every major cause as well as for totals.

TURNOVER OF SKILLED AND UNSKILLED OCCUPATIONS

The main divisions of turnover are given by quarters for occupational groups in Table 27 (p. 74). It will be seen that for every cause, turnover for skilled A occupations is below the average for the plant in every quarter, even though the total includes clerical and minor executive groups in which turnover is normally low. Likewise with minor exceptions, the turnover of the skilled A group is below the skilled B for every cause.

TABLE 27—MAIN DIVISIONS OF OCCUPATIONAL TURNOVER BY QUARTERS AT ONE LARGE CONCERN, 1923 AND 1924

OCCUPATIONAL GROUP	TOTALS										RESIGNATIONS									
	1923					1924					1923					1924				
	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.
Clerical.....	66.1	83.5	28.6	38.6	23.3	19.2	19.0	15.9	47.2	55.7	21.4	28.1	16.7	12.8	6.3	9.5	16.7	12.8	6.3	9.5
Minor Executive.....	25.5	21.5	26.1	22.2	12.0	15.6	7.0	5.2	12.7	9.2	16.3	15.4	10.3	10.4	1.7	1.8	10.3	10.4	1.7	1.8
Skilled A.....	60.7	81.4	68.3	77.9	43.5	49.1	19.9	20.4	21.4	59.9	43.1	34.5	18.8	26.2	11.3	9.5	18.8	26.2	11.3	9.5
Skilled B.....	212.5	156.1	138.6	88.1	97.1	108.2	111.9	81.6	84.0	79.0	47.4	22.1	22.8	42.9	56.0	39.8	22.8	42.9	56.0	39.8
All Skilled.....	99.5	98.9	84.5	80.1	55.3	61.8	38.9	32.7	37.4	64.4	44.1	31.8	19.7	29.8	20.5	15.5	19.7	29.8	20.5	15.5
Semi-skilled.....	90.8	176.6	124.6	87.0	79.7	90.9	52.2	32.6	27.1	87.5	61.5	37.1	30.9	31.5	17.4	14.2	30.9	31.5	17.4	14.2
Unskilled.....	233.6	310.9	339.8	254.7	225.3	197.5	121.3	85.5	67.7	146.7	151.6	87.1	50.7	60.3	43.9	30.7	50.7	60.3	43.9	30.7
Total.....	129.9	170.7	161.3	124.1	103.5	101.6	60.4	42.1	42.4	88.0	76.4	47.0	30.5	36.2	23.5	17.3	30.5	36.2	23.5	17.3
DISCHARGES																				
Clerical.....	0.0	0.0	0.0	0.0	6.6	3.2	0.0	3.2	18.9	27.8	7.2	10.5	0.0	3.2	12.7	3.2	0.0	3.2	12.7	3.2
Minor Executive.....	4.8	0.0	0.0	0.0	0.0	1.7	0.0	1.7	8.0	12.3	9.8	6.8	1.7	3.5	5.3	1.7	1.7	3.5	5.3	1.7
Skilled A.....	1.2	5.0	3.7	3.1	2.7	1.7	3.2	7.4	38.1	16.5	21.5	40.3	22.0	21.2	5.4	3.5	22.0	21.2	5.4	3.5
Skilled B.....	42.8	19.7	24.5	1.8	11.4	12.2	14.5	13.9	85.7	57.4	66.7	64.2	62.9	53.1	41.4	27.9	62.9	53.1	41.4	27.9
All Skilled.....	11.9	8.4	8.5	2.8	4.6	4.0	5.6	8.8	50.2	26.1	31.9	45.5	31.0	28.0	12.8	8.4	31.0	28.0	12.8	8.4
Semi-skilled.....	17.0	14.1	7.8	6.6	6.0	5.5	3.5	4.7	46.7	75.0	55.3	43.3	42.8	53.9	31.3	13.7	42.8	53.9	31.3	13.7
Unskilled.....	36.8	27.4	31.3	23.2	26.5	22.8	15.9	12.4	129.1	136.8	156.9	144.4	148.1	114.4	61.5	42.4	148.1	114.4	61.5	42.4
Total.....	19.4	14.1	13.9	9.2	10.6	9.3	6.9	7.6	68.1	68.6	71.0	67.9	62.4	56.1	30.0	17.2	62.4	56.1	30.0	17.2
LAY OFFS																				
Clerical.....	0.0	0.0	0.0	0.0	6.6	3.2	0.0	3.2	18.9	27.8	7.2	10.5	0.0	3.2	12.7	3.2	0.0	3.2	12.7	3.2
Minor Executive.....	4.8	0.0	0.0	0.0	0.0	1.7	0.0	1.7	8.0	12.3	9.8	6.8	1.7	3.5	5.3	1.7	1.7	3.5	5.3	1.7
Skilled A.....	1.2	5.0	3.7	3.1	2.7	1.7	3.2	7.4	38.1	16.5	21.5	40.3	22.0	21.2	5.4	3.5	22.0	21.2	5.4	3.5
Skilled B.....	42.8	19.7	24.5	1.8	11.4	12.2	14.5	13.9	85.7	57.4	66.7	64.2	62.9	53.1	41.4	27.9	62.9	53.1	41.4	27.9
All Skilled.....	11.9	8.4	8.5	2.8	4.6	4.0	5.6	8.8	50.2	26.1	31.9	45.5	31.0	28.0	12.8	8.4	31.0	28.0	12.8	8.4
Semi-skilled.....	17.0	14.1	7.8	6.6	6.0	5.5	3.5	4.7	46.7	75.0	55.3	43.3	42.8	53.9	31.3	13.7	42.8	53.9	31.3	13.7
Unskilled.....	36.8	27.4	31.3	23.2	26.5	22.8	15.9	12.4	129.1	136.8	156.9	144.4	148.1	114.4	61.5	42.4	148.1	114.4	61.5	42.4
Total.....	19.4	14.1	13.9	9.2	10.6	9.3	6.9	7.6	68.1	68.6	71.0	67.9	62.4	56.1	30.0	17.2	62.4	56.1	30.0	17.2

Barring the skilled B, in all other cases the rate of turnover varies inversely with the degree of skill.

SKILLED A

OCCUPATION	1923	1924
Carpenter	47.6	32.0
Electrician	79.8	28.4
Fitter	66.7	52.2
Joiner	247.1	84.4
Machinist	65.4	31.2
Pattern maker	146.7	25.0
Pipe fitter	88.4	39.3
Sheet metal worker	41.2	18.9

SKILLED B

OCCUPATION	1923	1924
Assembler	110.0	75.0
Fitter	109.5	92.3
Grinder	50.0	33.3
Layer out	68.3	38.1
Painter	222.5	163.2
Repairman	250.0	50.0

When detailed trades are considered within the grouping no such neat formula will explain the differences. Under skilled A, the turnover was low in 1923 for carpenters, fitters, machinists and metal workers; in 1924 all occupations were low except joiners. In the skilled B occupations, painters and repairmen were high in 1923, and painters and fitters in 1924. Though only a few of the occupations can be given in detail, there is a wide range in turnover figures for groups regarded as semi-skilled, the final turnover figure depending, of course, upon the proportion of high turnover jobs included in the group. The highest turnover in semi-skilled occupations is furnished by the large group of machine operators. Handymen, by contrast, have moderate rates. This may be explained by the

opportunity for promotion in the latter group. Among the machine operators the opportunity for change from plant to plant is facilitated by the standardization of equipment; the desire may be stimulated by the tendency to keep an expert on the same job.

SEMI-SKILLED

OCCUPATION	1923	1924
Crane operator	36.5	18.5
Driller	120.0	23.8
Handyman	85.4	42.5
Machine operator	216.7	112.5
Planer	140.0	12.5
Puncher	114.7	115.8

The importance of a high turnover in any group is, of course, in some measure conditioned upon the ratio that the group bears to the total payroll. It is essential for such a comparison to know the numbers on the active roll. For instance, in the firm just considered, though separation rates were higher for skilled B occupations than for semi-skilled, the large numbers in semi-skilled trades make that group of outstanding importance.

Table 28 shows the percentage employed in each year by grades of skill and the proportion of the total separations due to each grade.

Skilled A groups constituted about one-fourth of the payroll and contributed slightly less than that proportion to separations in 1922 and probably in 1921. In the next two years this group with one-fourth of all enrolled contributed only about one-eighth to the separations. The skilled B occupations made up 7 to 8 per cent of the plant's total and caused a trifle more than that proportion of the separations in 1922 and 1924. The proportion of separations about balanced with the proportion enrolled in 1923. Semi-skilled in

TABLE 28

OCCUPATIONAL GROUP	1921	1922		1923		1924	
	Proportion of Separations	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll
Skilled A.....	23.3	23.9	24.7	12.5	25.3	10.9	25.7
Skilled B.....	8.6	11.3	7.5	7.9	7.8	8.8	6.8
Semi-skilled.....	22.4	17.7	23.0	20.5	25.2	24.7	29.6
Unskilled.....	38.8	42.9	31.3	56.1	28.8	53.5	25.7
Clerical and Professional.....	6.9	4.2	13.5	3.0	12.9	2.1	12.2
Total.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0

every year caused a somewhat smaller proportion of total separations than their rank in the total force. In 1922 with 23 per cent of the force, they caused 17.7 per cent of the separations. In the next year, only one-fifth of all separations were by this group though it totalled one-fourth of the force. The high turnover of the unskilled occupations is of especial importance. Here are found from one-fourth to one-fifth of the payroll, contributing more than one-half of all plant separations in two of the years and 43 per cent in 1922, the year with the most favorable showing.

By consulting Table 27 (p. 74), the causes for turnover may be compared for occupational groups. It is true that lay offs were heaviest in the unskilled occupations. The highest turnover for discharges was also among the unskilled. This would account for a high general level of turnover in these occupations. Yet when resignations alone are considered, the rate is found to be highest in each year among unskilled groups. Resignations are next highest for skilled B groups and lowest for skilled A. The semi-skilled then rank next in stability in these years to the skilled tradesmen, and unskilled have the highest degree of instability when one considers the

figures from the point of view of total or voluntary causes for leaving. In other words, the same sequence of occupation is found when one considers main reasons for changes. The unskilled occupations have very high discharge and lay off rates. Despite these high rates, resignations are highest for unskilled, next highest, with one exception, for semi-skilled.

Discharges are inconsiderable for clerical employes and minor executives, and attention is not being directed to these groups.

PROPORTION OF SEPARATIONS BY MAJOR OCCUPATIONAL GROUPS

Analysis is rarely possible in terms of separations and proportions in the active force. For seven firms comparison is made of the proportion of separations due to each of the occupational groups in Table 29. Of course, the proportion of turnover caused by each occupation is dependent upon the numbers employed in the occupation. However, significant changes from period to period are seen in the figures.

About one-fifth of the turnover in Firm 7 was caused by the skilled groups, more than half by the unskilled. Firm 8 had a striking change in the last quar-

FOUR YEARS OF LABOR MOBILITY

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TABLE 29—PROPORTION OF SEPARATIONS BY OCCUPATIONAL GROUPS—QUARTER

OCCUPATIONAL GROUP	1923				1924			
	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.
<i>Firm 7</i>								
Clerical.....	2.4	2.0	0.7	1.1	0.9	0.8	1.4	1.6
Minor Executive....	1.8	1.2	1.3	1.4	0.9	1.2	0.9	1.0
Skilled.....	24.7	19.4	17.8	21.1	16.7	18.9	21.3	27.0
Semi-skilled.....	16.3	25.8	19.0	19.4	23.7	26.7	24.6	22.7
Unskilled.....	54.8	51.6	61.2	57.0	57.8	52.4	51.8	47.7
All Occupations....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 8</i>								
Clerical.....	2.2	4.4	5.4	1.5	1.8	1.6	3.1	2.6
Minor Executive....	....	....	0.4	0.4	....	0.3	....	....
Skilled.....	23.1	21.5	17.1	29.6	32.5	21.6	15.0	26.3
Semi-skilled.....	11.0	9.2	6.2	14.4	15.7	4.2	1.2	7.0
Unskilled.....	63.7	64.9	70.9	54.1	50.0	72.3	80.7	64.1
All Occupations....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 9</i>								
Clerical.....	3.0	2.6	7.1	10.1	9.3	6.3	10.4	12.5
Minor Executive....	0.3	....	....	0.9	....	....	....	....
Skilled.....	12.1	7.8	7.4	11.0	11.6	10.4	6.0	11.5
Semi-skilled.....	67.0	73.9	61.8	49.5	57.4	60.9	59.7	58.7
Unskilled.....	17.6	15.7	23.7	28.5	21.7	22.4	23.9	17.3
All Occupations....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 10</i>								
Clerical.....	5.1	3.1	6.1	4.6	8.4	11.0	5.6	7.1
Minor Executive....	2.0	1.3	0.4	2.6	4.6	2.4	4.2	2.0
Skilled.....	71.2	72.4	64.1	60.8	61.1	58.6	68.0	75.8
Semi-skilled.....	12.7	14.2	17.6	15.0	13.7	13.4	11.1	5.0
Unskilled.....	9.0	9.0	11.8	17.0	12.2	14.6	11.1	10.1
All Occupations....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 12</i>								
Clerical.....	41.8	39.5	52.7	45.8	42.2	47.1	49.4	37.8
Minor Executive....	0.7	1.8	1.6	0.3	2.1	1.0	1.7	0.2
Skilled.....	2.9	7.5	6.6	3.1	10.5	8.4	11.9	4.6
Semi-skilled.....	47.9	39.3	29.0	44.8	38.4	34.0	30.2	52.0
Unskilled.....	6.7	11.9	10.1	6.0	6.8	9.5	6.8	5.4
All Occupations....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 18</i>								
Unclassified.....	2.8	6.6	4.6	....	....	....	....	....
Clerical.....	....	....	....	....	2.6	....	....	....
Minor Executive....	....	....	....	2.1	2.5	....	....	1.6
Skilled.....	80.2	66.0	67.0	75.0	51.3	65.4	58.2	67.2
Semi-skilled.....	7.1	7.5	9.1	14.6	23.1	13.5	21.8	15.6
Unskilled.....	9.9	19.9	19.3	8.3	20.5	21.1	20.0	15.6
All Occupations....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 19</i>								
Clerical.....	....	....	22.9	20.0	12.1	21.9	27.6	33.3
Minor Executive....	....	....	1.4	....	3.0	....	....	....
Skilled.....	....	....	51.4	56.7	57.6	62.5	58.6	54.2
Semi-skilled.....	....	....	20.0	20.0	27.3	12.5	6.9	12.5
Unskilled.....	....	....	4.3	3.3	....	3.1	6.9	....
All Occupations....	....	....	100.0	100.0	100.0	100.0	100.0	100.0

ter of 1923 and the first half of 1924, when the proportion of skilled and semi-skilled increased in quarters, while unskilled contributed relatively little to the separations. In the next two quarters the proportion of unskilled exceeds any previous figure while semi-skilled drop to an inconsiderable fraction of the total.

Firm 9 differs from the others in importance of turnover among semi-skilled occupations. Stated approximately, from one-half to two-thirds of all the turnover in the plant was due to these occupations. Fortunately the proportion on the roll is available for the close of the year 1924. In so far as one may assume that the same proportion maintained throughout the year, it is evident that the separations of semi-skilled are excessive when compared with the number on the roll. The group is an important one, comprising 43 per cent of all employees and causing 59 per cent of the turnover.

FIRM 9, 1924

OCCUPATIONAL GROUP	PROPORTION OF SEPARATIONS	PROPORTION OF NO. ON PAYROLL
Skilled.....	10.3	21.0
Semi-skilled.....	59.3	43.3
Unskilled.....	21.3	17.1
Clerical and Minor Executive.....	9.1	18.6

The loss of skilled workers is proportionately very low, that of unskilled moderate, though relatively more than the proportion enrolled. The rate of loss among semi-skilled is about 37 per cent above the proportion in the active force, making this group the one of highest turnover in the plant.

Firms 10, 18 and 19 have their important problem centered about the skilled groups where one-half to three-

fourths of all separations occur. A comparison for Firm 18 for 1924 shows that the skilled occupations are the only ones that contribute greatly more than their proportionate share to the number of separations, bearing out the conclusion of the quarterly figures that the problem of turnover at this plant is made by the skilled groups.

FIRM 18, 1924

OCCUPATIONAL GROUP	PROPORTION OF SEPARATIONS	PROPORTION OF NO. ON PAYROLL
Skilled.....	62.2	48.9
Semi-skilled.....	17.2	27.2
Unskilled.....	19.4	16.2
Clerical and Minor Executive.....	1.2	7.7

The same sequence of occupations is found if resignations alone are considered. The table following is computed on the basis of 100 per cent for all resignations. The distribution between occupational groups follows the method used in Table 29.

LENGTH OF SERVICE BY OCCUPATIONAL GROUPS

While it is generally recognized that labor turnover occurs mainly in the first months of employment, there is little information as to how occupations differ in terms of length of service. Is the average length of service of skilled workers among separations longer than that of semi-skilled or unskilled? Does the length of service vary directly with skill? Or, again, is the length of service similar at the same plant from group to group or from year to year?

In the following tables the length of service of all separations is given for eight plants in 1923 and 1924.

The main subdivisions of these tables are shown in bar diagram form

TABLE 30—PROPORTION OF RESIGNATIONS BY OCCUPATIONAL GROUPS—QUARTERLY

OCCUPATIONAL GROUP	1923				1924			
	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec.
<i>Firm 7</i>								
Clerical.....	5.2	2.5	1.1	2.2	2.1	1.5	1.2	2.4
Minor Executive.....	2.8	1.0	1.6	2.5	2.6	2.3	0.6	0.8
Skilled.....	28.5	24.5	19.7	22.1	20.1	25.6	28.9	31.2
Semi-skilled.....	14.9	24.8	19.9	21.8	31.2	25.9	21.1	24.0
Unskilled.....	48.6	47.2	57.7	51.4	44.0	44.7	48.2	41.6
All Occupations.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 8</i>								
Clerical.....	2.3	2.8	3.9	2.1	1.0	1.3	1.2	1.8
Minor Executive.....	.....	.....	0.4	0.5	.....	0.4	.....	.....
Skilled.....	23.4	20.8	16.5	34.1	36.5	19.5	14.5	33.0
Semi-skilled.....	7.8	8.3	6.5	12.2	16.7	4.1	1.2	10.6
Unskilled.....	66.5	68.1	72.7	51.1	45.8	74.7	83.1	54.6
All Occupations.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 9</i>								
Clerical.....	1.8	1.9	8.2	7.4	3.0	9.6	6.7	11.5
Minor Executive.....	0.3	.....	.....	1.2	.....	.....	.....	.....
Skilled.....	11.3	7.3	7.6	7.4	10.1	9.6	4.4	10.3
Semi-skilled.....	68.7	75.7	58.5	60.5	65.7	64.4	62.2	62.8
Unskilled.....	17.9	15.1	25.7	23.5	21.2	16.4	26.7	15.4
All Occupations.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 10</i>								
Clerical.....	5.6	3.2	7.8	5.3	7.9	11.1	6.0	7.6
Minor Executive.....	1.2	1.1	.....	1.3	5.3	.....	2.0	1.5
Skilled.....	74.4	74.8	66.3	64.5	65.8	61.9	72.0	77.3
Semi-skilled.....	12.4	12.2	16.9	9.2	11.8	7.9	12.0	6.0
Unskilled.....	6.4	8.7	9.0	19.7	9.2	19.1	8.0	7.6
All Occupations.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 12</i>								
Clerical.....	41.7	39.8	58.6	46.5	42.9	44.9	48.8	40.0
Minor Executive.....	0.6	2.1	1.9	0.5	2.3	1.2	2.4	0.6
Skilled.....	2.4	7.7	5.8	2.8	9.3	7.8	11.6	8.3
Semi-skilled.....	49.2	38.7	26.3	44.0	39.5	35.6	29.5	47.6
Unskilled.....	6.1	11.7	7.4	6.2	6.0	10.5	7.7	3.5
All Occupations.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 18</i>								
Unclassified.....	3.1	7.0	.....	.....	.....	.....	.....	.....
Clerical.....	.....	.....	.....	2.4	4.5	.....	.....	.....
Minor Executive.....	.....	.....	.....	.....	4.6	.....	.....	.....
Skilled.....	81.4	67.0	69.9	73.2	50.0	80.0	62.9	74.5
Semi-skilled.....	5.6	7.4	10.9	17.1	27.3	10.0	20.0	13.7
Unskilled.....	9.9	18.6	19.2	7.3	13.6	10.0	17.1	11.8
All Occupations.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>Firm 19</i>								
Clerical.....	.....	.....	18.2	17.1	17.6	18.5	20.7	27.5
Minor Executive.....	.....	.....	3.0	.....	1.5	.....	.....	.....
Skilled.....	.....	.....	54.6	58.5	50.0	59.3	62.1	52.5
Semi-skilled.....	.....	.....	20.2	19.5	23.5	18.5	10.3	17.5
Unskilled.....	.....	.....	4.0	4.9	7.4	3.7	6.9	2.5
All Occupations.....	.....	.....	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 31—PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS BY LENGTH OF SERVICE, 1923

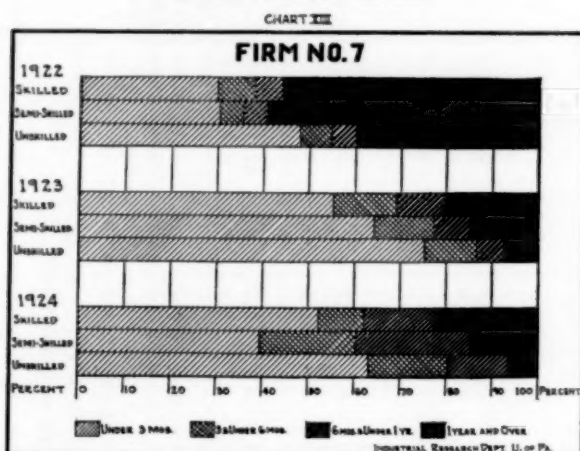
OCCUPATIONAL GROUP	LENGTH OF SERVICE														TOTAL
	Under 1 Wk.	1 Wk. and Under 1 Mo.	1 Mo. and Under 3 Mos.	3 Mos. and Under 6 Mos.	6 Mos. and Under 1 Yr.	1 Yr. and Under 2 Yrs.	2 Yrs. and Under 3 Yrs.	3 Yrs. and Under 4 Yrs.	4 Yrs. and Under 5 Yrs.	5 Yrs. and Under 10 Yrs.	10 Yrs. and Under 15 Yrs.	15 Yrs. and Under 20 Yrs.	20 Yrs. and Over	Un- known	
Firm 7	.....	6.3	9.4	15.6	9.4	4.7	9.4	4.6	18.8	17.2	4.6	....	....	....	100.0
	3.5	25.0	26.7	13.8	10.2	3.1	2.9	1.9	4.8	5.7	1.5	0.1	0.8	....	100.0
	3.1	36.9	24.2	13.2	7.9	2.0	0.9	2.4	3.0	4.8	1.2	0.2	0.2	....	100.0
	3.9	42.3	29.0	11.5	5.8	1.7	1.7	1.3	1.5	0.7	0.3	0.1	0.2	....	100.0
Firm 8	2.8	31.4	25.7	8.6	8.6	8.6	2.9	....	....	....	....	....	11.4	....	100.0
	5.0	20.7	16.9	19.8	14.3	7.6	3.8	5.1	1.7	3.4	1.3	....	....	0.4	100.0
	3.8	24.5	29.2	17.0	7.6	5.7	6.6	1.9	0.9	2.8	....	....	....	....	100.0
	13.6	38.7	24.9	11.8	4.8	2.6	0.8	0.8	0.5	0.8	....	....	....	0.7	100.0
Firm 9	3.3	16.4	34.4	8.2	19.7	9.8	1.6	....	3.3	3.3	....	....	....	....	100.0
	18.6	25.6	19.4	13.9	17.8	2.3	0.8	....	1.6	....	....	....	....	....	100.0
	24.3	34.8	18.0	9.4	7.3	5.5	0.3	0.1	....	0.1	....	....	....	0.2	100.0
	17.6	28.7	28.0	10.8	9.3	5.2	....	....	....	0.4	....	....	....	....	100.0

Firm 10												
Clerical	7.5	12.5	5.0	15.0	25.0	20.0	10.0	2.5	.....	2.5	.....	100.0
Skilled	8.7	24.6	21.3	12.3	12.7	12.0	3.3	1.0	1.7	1.7	0.7	100.0
Semi-skilled	3.8	18.9	22.6	15.1	17.0	13.2	7.5	.....	.....	1.9	.....	100.0
Unskilled	8.6	27.6	17.3	12.1	24.1	6.9	1.7	.....	.....	1.7	.....	100.0
Firm 12												
Clerical	2.8	25.9	24.1	10.6	11.1	14.3	5.0	6.0	0.1	.....	0.1	100.0
Skilled	2.2	8.1	14.4	10.8	12.6	28.4	10.4	11.3	1.3	0.5	.....	100.0
Semi-skilled	3.8	32.2	29.0	13.7	8.6	7.4	2.6	2.1	0.3	0.1	0.2	100.0
Unskilled	2.1	19.9	23.0	18.9	15.7	16.2	2.1	1.6	0.5	.....	.....	100.0
Firm 18												
Clerical	.....	.....	.....	.....	.....	100.0	.....	.....	.....	.....	.....	100.0
Skilled	12.9	16.6	21.5	13.5	15.3	13.5	5.5	1.2	.....	.....	.....	100.0
Semi-skilled	11.1	8.9	33.3	15.6	11.1	11.1	6.7	2.2	.....	.....	.....	100.0
Unskilled	19.6	21.5	19.6	5.9	15.7	11.8	5.9	.....	.....	.....	.....	100.0
Firm 19												
Clerical	2.2	6.7	17.8	20.0	15.6	8.9	6.7	4.4	4.4	11.1	2.2	100.0
Skilled	2.4	13.0	14.6	11.4	22.8	15.5	4.1	2.4	3.3	6.5	1.6	100.0
Semi-skilled	2.5	25.6	15.4	12.8	17.9	15.4	.....	.....	.....	2.6	2.6	100.0
Unskilled	.....	16.7	25.0	8.3	16.7	.....	16.7	8.3	.....	8.3	.....	100.0

for the skilled, unskilled and semi-skilled groups. The light cross-hatched area at the left of the bar shows the proportion with less than three months of service. The second and third cross-hatched areas show the percentages leaving in three and under six months

lose least among short service employees. In the case of this firm, then, no simple direct relationship between length of service and skill can be predicated from period to period. By consulting the table, it is apparent that the plant loses few in the first week of employment,

PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS
BY LENGTH OF SERVICE



and six and under twelve months respectively. The black areas at the ends of the bars include all leaving with one or more years of experience at this plant.

Chart XIII indicates that in 1923 length of service at Firm 7 varied directly with skill. The occupational class with the highest proportion of less than three months' experience among separated employees is the unskilled. It is lowest for the proportion with a year or more of service. In these intervals the semi-skilled is next.

In 1922 and 1924 this conclusion is found to be true for unskilled only. The semi-skilled in both years have a low proportion of separations in the first three months. Even the one-year-and-over group is measurably larger for semi-skilled in 1922 than for skilled. In both years the semi-skilled relatively

and of those leaving in this interval, the tendency for skilled men to leave in the first few days is most marked. On the other hand, in the next three weeks the loss of unskilled is very heavy. In skilled occupations the proportionate loss in the first month was about the same in both years (28 per cent). In 1923, the losses of semi-skilled and unskilled had been very high in the first month (40 and 46 per cent), and there was a marked decrease in the proportions in these intervals in 1924 (15 and 27 per cent). About 12 per cent of the separations in both skilled and semi-skilled occurred in each of the next two months in both years. When the six-months-to-one-year interval is reached, separations of less than 2 per cent per month are found in all groups except the semi-skilled in 1924. Small numbers of employees leaving with ten

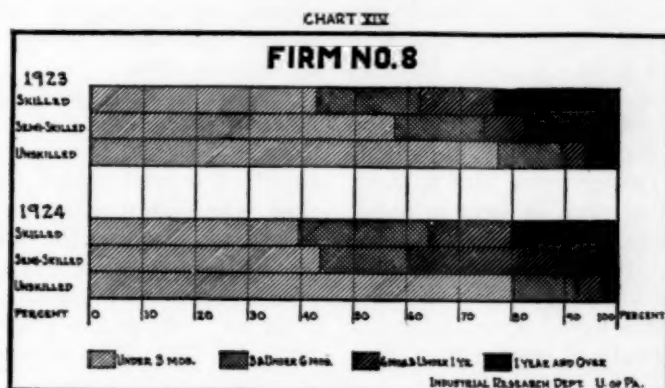
or more years of experience, show a situation that is especially favorable with the large proportion of long service employees on the roll.

In both years at Firm 8, length of service among separated employees varies directly with skill. The loss of unskilled in the first three months includes more than three-fourths of all separations for this group. The semi-skilled differ from the skilled in having more separations in the first three months. The significant intervals in length of service are shown in the bar diagram below.

tenth to one-fifth. The high rate of loss in the three-to-six-months period is especially notable.

Firm 9 experiences heavy losses in the first week of employment. This is particularly true for skilled and semi-skilled occupations. Even in the three following weeks, the loss is proportionately greater among semi-skilled than among unskilled. The next two months show heavy losses for unskilled, but not great enough to offset the first periods of high turnover among semi-skilled. The chart shows that the proportion of semi-skilled leaving within the first

PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS BY LENGTH OF SERVICE



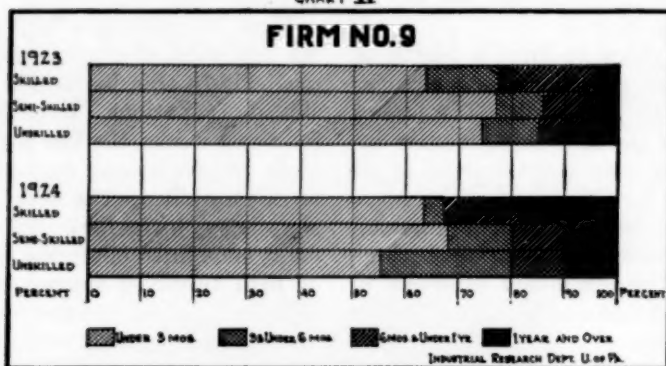
The figures in Tables 31 and 32 (pp. 80-83) show that the loss of skilled men is moderate in the first week, though in this interval are found 14 to 17 per cent of all unskilled. A significant loss of skilled occurred in the three-to-six-months interval in both years; the highest loss of semi-skilled in the one-to-three-months interval in 1924, and in the unskilled one-week-to-one-month. When the over-one-year groups are reached, the unskilled had not more than 2 to 5 per cent in either year; the skilled had one-fourth to one-fifth of separations and the semi-skilled one-

three months exceeds that of the unskilled in both years. In the over-one-year group there is a slight excess of semi-skilled over skilled in 1923 and a balance in the proportions in 1924. In this case, then, the average of continuous employment among separations would be longer for unskilled than for semi-skilled in each of the years considered.

Firm 10 differs in every respect from those already considered. Skilled workers have a shorter length of service than semi-skilled or unskilled. In each year the semi-skilled have the

PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS BY
LENGTH OF SERVICE

CHART XV



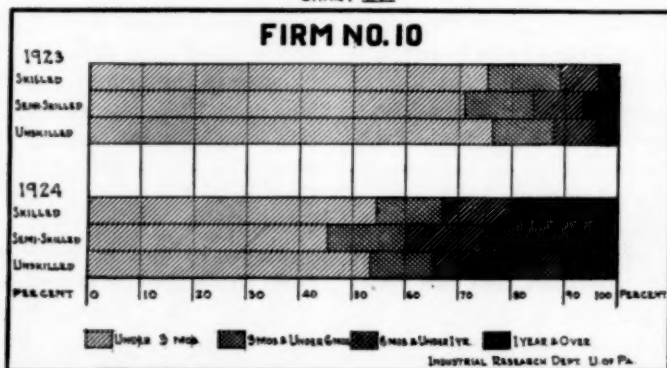
longest records for service. The loss is greatest for skilled occupations in the first four weeks. In 1924 the length of service of all groups is longer than in 1923, though this change affects all groups without making a difference in the relative ranking of each. In evaluating these changes from year to year, market factors must be kept in mind. New employees were added with consequent high turnover throughout 1923, while few additions to the roll occurred in 1924. This would account for the change in length of service from year

to year, but would scarcely account for shorter service among skilled than among semi-skilled in both years and unskilled in 1923.

Firm 18 had the same experience as Firm 10 with respect to skilled occupations in 1923, but in the next year the length of service varied directly with skill. One-eighth of the skilled separations took place in the first week of employment, a period when the loss of unskilled reached about one-fifth of the total for 1923 and a trifle over one-tenth for 1924. The areas charted for

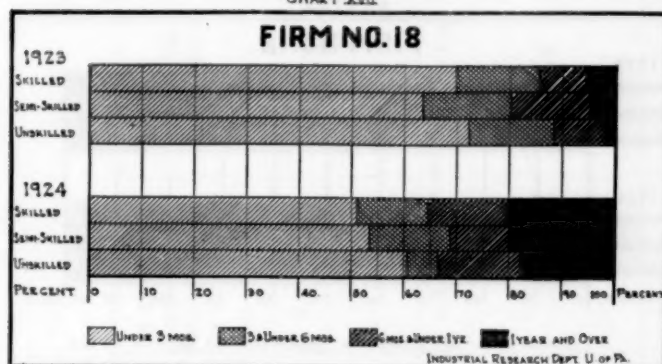
PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS BY
LENGTH OF SERVICE

CHART XVI



PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS BY
LENGTH OF SERVICE

CHART XXVII



the over-one-year group lengthen in the artisan groups from 5 per cent in 1923 to about 20 per cent in the following year.

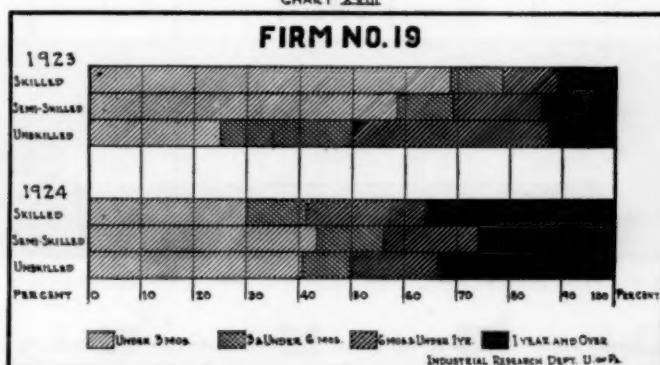
Judged from the point of view of separations, the experience of the two years at Firm 19 is contradictory. In the first year, length of service varies inversely with skill. The unskilled were massed in the three-to-six-months period. In the next year, there are many long service employees among the skilled and unskilled, while semi-skilled tend to stay a shorter period with the plant than either of the other groups.

The experience of Firms 18 and 19 is contradictory with no conformity between the experiences of the two years.

The last firm to be discussed in this comparison is Firm 12 in Tables 31 and 32 (pp. 80-83). Length of service at this firm not only varies directly with skill but the average for skilled groups is very high. The most critical period for these occupations was postponed until the one-to-two-year interval in 1923, and in the interval just below in 1924. Semi-skilled and unskilled were highest in both years in the first four weeks with the plant, but a heavy rate of loss

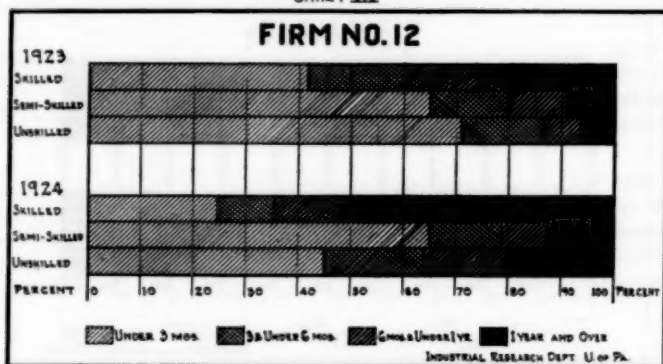
PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS BY
LENGTH OF SERVICE

CHART XXVIII



PROPORTION OF SEPARATIONS IN OCCUPATIONAL GROUPS BY LENGTH OF SERVICE

CHART XIX



continued during the two following months.

On the whole, there is a tendency at these plants for length of service to vary with skill, but there are enough cases where opposite tendencies prevail to

require careful examination of other factors. For instance, if *laborers* are separated from other occupations classed as unskilled, their average length of service is lower than for all unskilled occupations. Such a separa-

PROPORTION OF SEPARATIONS OF LABORERS BY LENGTH OF SERVICE

CHART XX

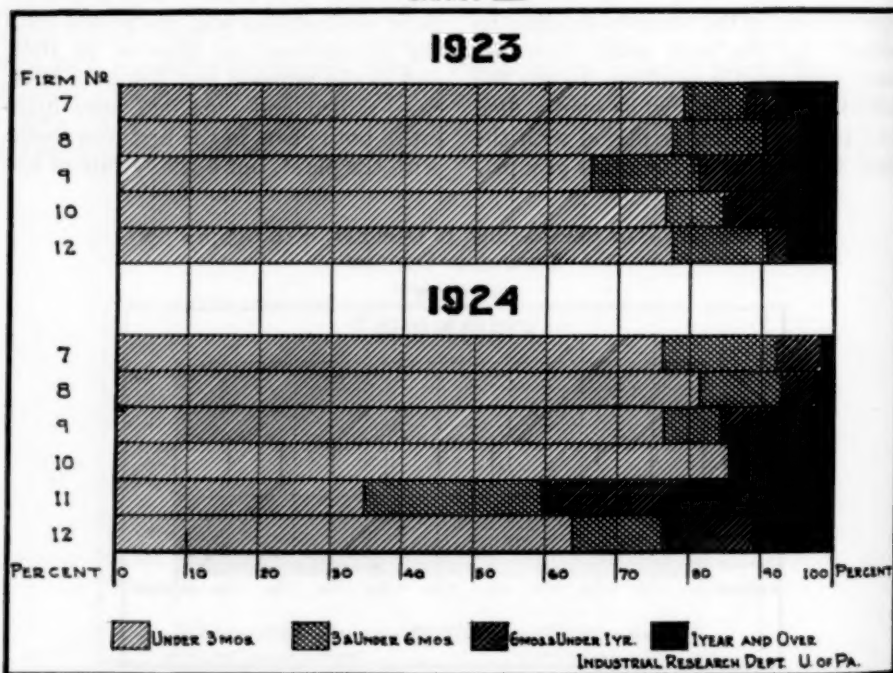


TABLE 33—PROPORTION OF SEPARATIONS AMONG COMMON LABORERS BY LENGTH OF SERVICE, 1923-1924

Firm Nos.	LENGTH OF SERVICE														Total
	Under 1 Wk.	1 Wk. and Under 1 Mo.	1 Mo. and Under 3 Mos.	3 Mos. and Under 6 Mos.	6 Mos. and Under 1 Yr.	1 Yr. and Under 2 Yrs.	2 Yrs. and Under 3 Yrs.	3 Yrs. and Under 4 Yrs.	4 Yrs. and Under 5 Yrs.	5 Yrs. and Under 10 Yrs.	10 Yrs. and Under 15 Yrs.	15 Yrs. and Under 20 Yrs.	20 Yrs. and Over	Un-known	
1923	7.2	53.6	17.3	9.4	4.3	1.2	2.7	1.4	0.7	1.5	0.5	0.2	....	....	100.0
	11.7	39.7	26.0	13.0	4.7	2.5	0.6	0.4	....	0.7	....	....	....	0.7	100.0
	4.8	52.4	9.5	14.3	14.3	4.7	....	....	....	....	....	....	....	....	100.0
	....	46.1	30.8	7.7	7.7	7.7	....	....	....	....	....	....	....	....	100.0
	10.2	35.7	31.6	13.3	3.1	4.1	2.0	....	....	....	....	....	....	....	100.0
Total....	9.6	44.9	23.0	11.6	4.6	2.3	1.4	0.7	0.3	0.9	0.2	0.1	....	0.4	100.0
1924	2.1	29.1	45.0	15.9	6.2	1.1	0.3	....	....	....	0.3	....	....	....	100.0
	16.7	44.1	21.0	11.1	4.6	1.7	0.7	....	....	....	....	....	....	0.1	100.0
	15.4	30.8	30.7	7.7	7.7	7.7	....	....	....	....	....	....	....	....	100.0
	....	42.9	42.9	....	....	14.2	....	....	....	....	....	....	....	....	100.0
	4.2	5.8	24.8	24.8	22.3	13.2	....	0.8	3.3	0.8	....	....	....	....	100.0
Total....	10.4	35.4	29.0	13.7	7.1	3.1	0.5	0.2	0.3	0.1	0.1	....	....	0.1	100.0

tion on Chart XX gives 80 per cent or more with a continuous record of less than three months.

The experiences of the two years show a loss of about 80 per cent at all firms in the length of service intervals under three months. Of the individual firms, one lost 70 per cent in 1923 and in 1924 two lost less than 80 per cent, one having only 30 per cent in the under-three-months period. With these exceptions the experiences of firms were similar.

COMPARISON OF LENGTH OF SERVICE OF SEPARATIONS AND ACTIVE FORCE BY GRADES OF SKILL

Up to this point length of service by occupational groups has been considered for employes leaving the plant. Since the turnover falls unequally upon sections of the working force, it would be desirable to compare the length of service of the various grades of skill in the active force. Is there a common difference in distribution between active and separated employes in the different grades of skill? Data in answer to this inquiry have not been accumulated over a long period for many firms. For one firm where records cover most of the four-year period, analyses are given on the same basis of classification of occupations as used in the first part of this chapter, (p. 69.)

In 1922, 50 per cent of skilled A occupations were filled by employes with five or more years' service with the company. This long service group contributed less than 17 per cent of all separations. The introduction of new employes in 1923 reduced the five-years-and-over group to 47 per cent of the roll, among whom only 11 per cent of all skilled A separations occurred. With the exception of this year, two-thirds to three-fourths of skilled A employes left with a record of one or more years with the plant, and 40 to

50 per cent with more than five years. In every year the number of separations in the one-year-and-under periods is greater than their relative numbers on the roll.

By contrast with the 50 per cent of skilled A having records of five years and over, skilled B have about one-third in 1922 and 1923 in these extreme long service groups. One-fourth have records of one to five years. In the first three months with the company the amounts contributed to separations are very high by comparison with the proportional amounts on the roll.

Among the semi-skilled, the groups with five or more years of service are surprisingly high, though the proportion in these intervals decreased in each year considered. In two years, more than two-thirds of the semi-skilled force had one year or more of service; in 1923 the new hirings overbalanced the short service groups, leaving 55 per cent of the total semi-skilled over one year. It should be mentioned that this conspicuous increase in proportions under one year is evident in every group, even that of minor executives, though the increase is smallest among these and next smallest for skilled occupations.

In the various years from 14 to 17 per cent of the unskilled in the active force had five or more years of service. Only 2 to 4 per cent of the separations occurred among these long service employes. Thus, one may say that whatever grade of skill is considered, the turnover among long service groups is not excessive. Where the turnover is as high as that in unskilled occupations, it is particularly significant to find a marked stability among long service employes. In the figures below, the stability of unskilled is marked not only in the five-year intervals but in all cases above one or two years. The critical period appears to be in

TABLE 34—LENGTH OF SERVICE OF SKILLED "A" OCCUPATIONS, 1921-1924

LENGTH OF SERVICE	1921		1922		1923		1924	
	Proportion of Separations	Proportion of Separations	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll
Under 1 mo.....	2.8	9.4	1.6	8.7	19.5	19.0	6.2	
1 mo. and under 3 mos.....	7.1	13.3	8.5	7.2	28.8	21.5	5.7	
3 mos. " " 6 mos.....	13.4	6.7	3.5	8.0	12.7	10.9	8.3	
6 mos. " " 1 yr.....	21.3	4.4	10.8	10.1	11.9	20.3	6.1	
Total under 1 yr.....	44.6	33.8	24.4	34.0	72.9	71.7	26.3	
1 yr. and under 2 yrs.....	20.7	15.7	1.2	7.1	3.4	13.0	18.6	
2 yrs. " " 3 yrs.....	11.5	10.2	6.7	3.2	3.2	2.8	9.3	
3 yrs. " " 4 yrs.....	17.3	10.0	5.3	3.3	2.5	0.8	1.0	
4 yrs. " " 5 yrs.....	5.4*	13.8	12.0	5.2	7.2	2.0	3.2	
5 yrs. " " 10 yrs.....	.....	16.5*	20.7	21.2	7.4	6.5	18.8
10 yrs. " " 15 yrs.....	.....	.....	15.8	12.5	1.9	1.6	8.7
15 yrs. " " 20 yrs.....	.....	.....	6.6	6.1	0.2	0.4	7.6
20 yrs. and over.....	.....	.....	7.3	7.4	1.3	1.2	6.5
Unknown.....	0.5	.....	.....	.....	.....	.....	.....

* 5 years and over.

TABLE 35—LENGTH OF SERVICE OF SKILLED "B" OCCUPATIONS, 1921-1924

LENGTH OF SERVICE	1921		1922		1923		1924	
	Proportion of Separations	Proportion of Separations	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll
Under 1 mo.	13.6	30.6	10.5	5.1	42.7	39.3	3.9	3.9
1 mo. and under 3 mos.	18.5	14.7	15.9	14.0	23.4	27.6	3.9	3.9
3 mos. " " 6 mos.	21.3	10.5	4.8	8.4	13.6	8.0	8.4	8.4
6 mos. " " 1 yr.	19.3	8.6	6.7	14.0	7.5	9.5	3.9	3.9
Total under 1 yr.	72.7	64.4	37.9	41.5	89.2	84.4	20.1	20.1
1 yr. and under 2 yrs.	10.9	14.7	2.4	6.5	2.7	7.6	20.2	20.2
2 yrs. " " 3 yrs.	6.5	7.6	10.1	5.1	2.4	3.0	8.4	8.4
3 yrs. " " 4 yrs.	7.4	3.6	4.3	4.2	0.9	0.5	1.0	1.0
4 yrs. " " 5 yrs.	2.2*	5.0	8.2	5.1	0.9	0.5	7.4	7.4
* 5 yrs. " " 10 yrs. ....	.....	4.7*	17.8	19.5	3.0	3.0	24.2	24.2
10 yrs. " " 15 yrs. ....	.....	.....	10.6	8.8	0.9	.....	8.4	8.4
15 yrs. " " 20 yrs. ....	.....	.....	5.8	6.5	.....	0.5	5.9	5.9
20 yrs. and over. ....	.....	.....	2.9	2.8	.....	0.5	4.4	4.4
Unknown.	0.3	.....	.....	.....	.....	.....	.....	.....

* 5 years and over.

TABLE 36—LENGTH OF SERVICE OF SEMI-SKILLED OCCUPATIONS, 1921-1924

LENGTH OF SERVICE	1921		1922		1923		1924	
	Proportion of Separations	Proportion of Separations	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll
Under 1 mo.....	1.0	16.6	3.5	11.2	14.9	6.6	14.9	6.6
1 mo. and under 3 mos.....	4.7	13.6	15.2	12.5	24.2	12.4	24.4	12.4
3 mos. " " 6 mos.....	9.5	5.2	6.3	8.1	13.2	5.1	21.2	5.1
6 mos. " " 1 yr.....	19.2	5.7	7.8	13.6	7.9	7.3	24.8	7.3
Total under 1 yr.....	34.4	41.1	32.8	45.4	85.3	31.4	85.3	31.4
1 yr. and under 2 yrs.	20.4	10.1	1.6	9.6	2.0	26.1	8.5	26.1
2 yrs. " " 3 yrs.....	20.4	12.2	3.8	2.1	0.9	11.3	2.0	11.3
3 yrs. " " 4 yrs.....	21.7	13.0	8.6	2.9	2.4	0.8	0.7	0.8
4 yrs. " " 5 yrs.....	3.1*	13.6	14.3	5.9	3.0	1.7	0.4	1.7
5 yrs. " " 10 yrs.....	.....	10.0*	21.5	19.9	4.8	17.1	2.3	17.1
10 yrs. " " 15 yrs.....	.....	.....	11.1	8.1	1.2	5.1	0.2	5.1
15 yrs. " " 20 yrs.....	.....	.....	4.1	4.0	0.2	4.1	0.2	4.1
20 yrs. and over.....	.....	.....	2.2	2.1	0.2	2.3	0.4	2.3
Unknown.....	.....	.....	.....	.....	.....	0.1	.....	0.1

* 5 years and over.

TABLE 37—LENGTH OF SERVICE OF UNSKILLED OCCUPATIONS, 1921-1924

LENGTH OF SERVICE	1921		1922		1923		1924	
	Proportion of Separations		Proportion of Separations		Proportion of Separations		Proportion of Separations	
Under 1 mo.	4.8		29.5	14.9	46.2	17.3	26.9	15.7
1 mo. and under 3 mos.	10.4		18.3	20.7	29.0	18.8	36.3	11.3
3 mos. " " 6 mos.	15.5		6.9	6.7	11.5	11.6	17.6	8.9
6 mos. " " 1 yr.	23.1		5.4	12.3	5.8	13.1	13.1	14.2
Total under 1 yr.	53.8		60.1	54.6	92.5	60.8	93.9	50.0
1 yr. and under 2 yrs.	19.1		14.0	3.0	1.7	6.9	3.2	21.2
2 yrs. " " 3 yrs.	14.1		8.1	10.1	1.7	4.1	0.3	6.4
3 yrs. " " 4 yrs.	11.0		7.9	8.8	1.3	5.6	0.3	0.9
4 yrs. " " 5 yrs.			5.6	9.3	1.5	6.1	0.5	4.3
5 yrs. " " 10 yrs.	2.0*		4.3*	9.0	0.7	11.4	1.5	11.9
10 yrs. " " 15 yrs.				2.9	0.3	2.8	0.2	2.0
15 yrs. " " 20 yrs.				1.4	0.1	1.5	0.1	2.0
20 yrs. and over				0.9	0.2	0.8		1.2
Unknown								

* 5 years and over.

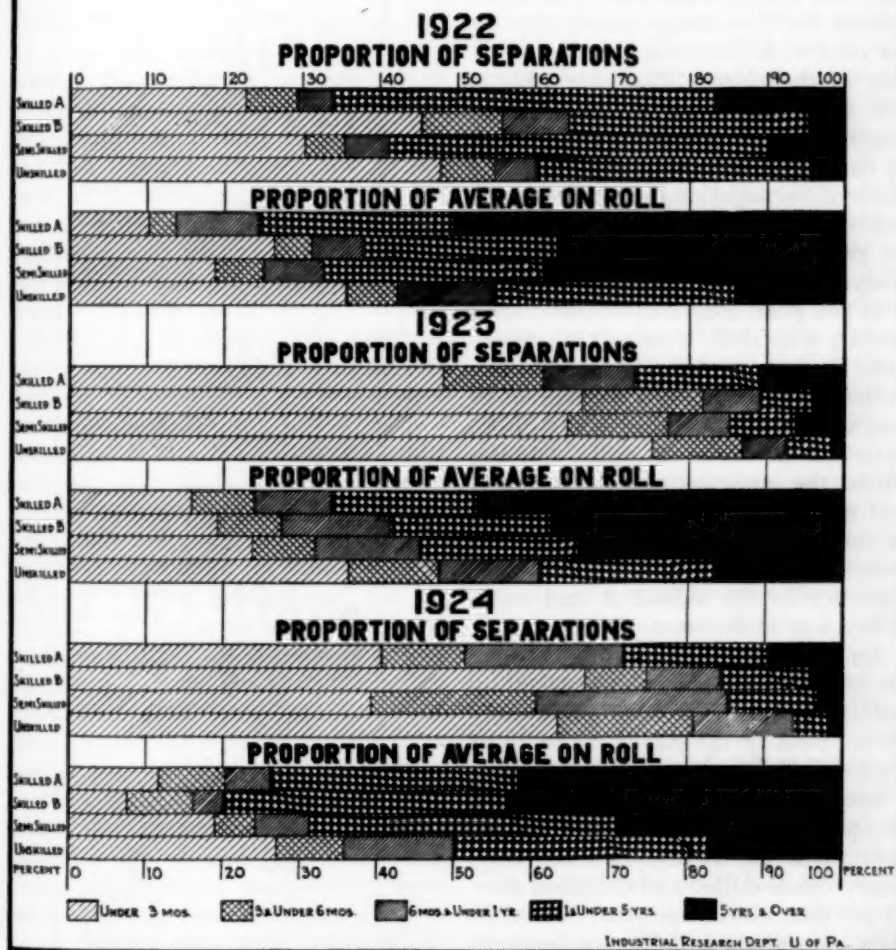
the first month of service and rarely extends beyond the first three months.

The length of service is shown for separations and number on the rolls in bar diagram form for the three years. In each year the proportion on the roll in each grade of skill is shown in the section below the terminations and

the same cross-hatching is used to represent similar length of service periods. The small area in black measures the separations among five-year-and-over employees in each rank of skill. Note how small the black area for separations is in relation to the corresponding black area below from which

CHART XXI

LENGTH OF SERVICE FOR OCCUPATIONS BY GRADE OF SKILL



potential loss was conceivable. The black areas of separations for skilled A occupations represent 20 to 30 per cent actual loss in terms of the potential risk. In 1922, the semi-skilled were more stable than the skilled B. At the same time the length of service of separations was greater especially in the one-and-under-five-year intervals. In other groups length of service varied directly with skill. In the next year the advance in length of service favored the skilled B occupations, but the proportion of separations in the first three months was amazing. Consultation of the chart shows 66 per cent of all separations for the group among the 20 per cent with less than three months' stay in the plant. The year 1924 is still more favorable to skilled B in length of service of numbers on the roll as compared with semi-skilled. The loss in the occupations was in large part due to heavy lay off among short service groups. In terms of the payroll analysis, with the exception of skilled B in one year, length of service varies directly with skill. Among the separations the loss of skilled B occupations in the first three months is too great to warrant the simple conclusion of direct variation in terms of skill. On the whole, the tendency was for skilled B and unskilled occupations to increase in the proportion found in the five-years-and-over group, whereas the tendency in the skilled A and semi-skilled was to decrease.

An interesting comparison between the length of service groups ranked by skill is furnished in another plant where 50 per cent of the roll is made up of semi-skilled.

Seventy-five per cent of all skilled occupations have one or more years' continuous experience with the company. Semi-skilled and unskilled show 54 per cent above one year. There is, then, no marked difference between

OCCUPATIONAL GROUP	LENGTH OF SERVICE														TOTAL
	Under 1 Wk.	1 Wk. and Under 1 Mo.	1 Mo. and Under 3 Mos.	3 Mos. and Under 6 Mos.	6 Mos. and Under 1 Yr.	1 Yr. and Under 2 Yrs.	2 Yrs. and Under 3 Yrs.	3 Yrs. and Under 4 Yrs.	4 Yrs. and Under 5 Yrs.	5 Yrs. and Under 10 Yrs.	10 Yrs. and Under 15 Yrs.	15 Yrs. and Under 20 Yrs.	20 Yrs. and Over	Un-known	
Skilled.....	1.6	4.0	6.5	4.8	9.7	20.2	25.0	12.9	....	11.3	4.0	....	....	....	100.0
Semi-skilled.....	4.3	4.3	7.0	12.5	17.6	21.1	19.5	7.8	0.8	4.7	0.4	....	....	....	100.0
Unskilled.....	4.9	7.9	3.0	17.8	11.9	24.8	14.8	12.9	....	2.0	....	....	....	....	100.0
Clerical.....	....	0.9	4.5	1.8	7.3	9.1	11.8	1.8	8.2	36.4	10.9	0.4	....	0.9	100.0

semi-skilled and unskilled in these intervals nor is the difference great if other intervals are considered. In turnover, however, the rates are measurably higher in the first four weeks among semi-skilled than among those reported as unskilled.

At a third plant where the proportion of skilled employees is more than the semi-skilled and unskilled taken together, an analysis of the working force shows 56 per cent of the skilled, 50 per cent of the semi-skilled, and 34 per cent of the unskilled with more than one year of continuous service. Even above five years there were 17 per cent of skilled, 24 per cent of semi-skilled, and 14 per cent unskilled in the active force. No turnover is reported in groups above five years of service whatever the rank of skill considered. In the first three months occurred 51 per cent of all skilled separations, 53 per cent of semi-skilled, and 61 per cent of unskilled. In the main when active forces are considered, length of service varies with skill.

In placing emphasis upon grade of skill it is recognized that other factors have an influence upon the turnover of an occupation. Men have been grouped according to the value assigned to the occupation by the plant without regard to departmental organization. Turnover does not maintain a balance in different parts of an organization even when the same occupations are involved. While a turnover figure for a whole plant gives the actual loss of employees, some departments often cause much of the turnover. One large department with 8 per cent of the force had 18 per cent of all plant separations in 1923, while the machine shop with nearly the same size of force furnished only 2.5 per cent of the separations. Some departments continually cause more turnover than others. Many of these differences defy explanation.

Four departments of the same industry, essentially alike in distribution of occupation, have vastly different turnover. Department B has continued for three years to have higher turnover in every quarter than any of the other departments. Each department may be said to be a complete operating unit. None of the general departments of the plant are included in these, and while different numbers are involved, there is about the same proportion of each occupation in the total. The table shows quarterly and yearly turnover rates.

It is evident that in 1923 the turnover for Department B was more than double that of the next highest department, and treble that of either the others. In other words, though only 17 per cent of all men in the company are enrolled in this department, it occasioned one-third of the turnover for the plant in 1922 and 43 per cent in 1923. Location and other factors unconnected with the occupations influence such cases. While a turnover figure for an occupation gives the actual loss of employees in that grade of skill, some departmental organization may influence the figure adversely or favorably.

High turnover for an occupation may fail to attract attention because of the distribution throughout a number of departments. Or the supervision of one department may raise the rates of turnover for an occupation normally low in other departments.

In our grouping such influences are not isolated for *particular* study. Plant equipment and grade of product influence the turnover of skilled workmen. Among the journeymen in skilled trades, turnover may be high in the first years following apprenticeship. The same trades may show a very low turnover among older experienced workmen. The comments of skilled

workmen indicate that they make changes in many cases to acquire skill and experience even at the risk of some immediate loss in remuneration. All these factors make inevitable some conflict of findings in studying the incidence of turnover in skilled trades at different periods and in different plants.

Our interest in the comparison of occupations does not center primarily upon the stability of skilled and unskilled groups. Here conclusions are rarely conflicting. The area of doubt is in the skilled trades common to many types of industry, and the skilled trades peculiar to one type or branch of indus-

try by contrast with machine operations and other specialized occupations normally classed as semi-skilled. With a few significant exceptions, the skilled occupations peculiar to many types of industry have shown the lowest turnover rates. Our data concerning skilled occupations peculiar to a single type of industry are very meagre, but are consistent from period to period in showing a higher rate of turnover among these occupations than among the "crafts." No other statistical data have been found on this subject, but the result does not tally with the impressions of executives or the opinions of workmen.

TABLE 38—ANNUAL TURNOVER IN DEPARTMENTS OF ONE CONCERN—
QUARTERLY AND YEARLY, 1921-1924

QUARTERLY	DEPARTMENTS			
	A	B	C	D
<i>1921</i>				
January-March	82.9	94.0	57.1	100.0
April-June	275.4	259.2	237.9	201.4
July-September	47.7	72.1	85.6	19.8
October-December	188.3	105.8	123.0	92.8
<i>1922</i>				
January-March	56.1	97.4	73.2	58.5
April-June	122.4	257.7	197.8	134.9
July-September	155.6	266.0	109.4	158.1
October-December	163.2	184.8	43.4	161.2
<i>1923</i>				
January-March	70.2	280.8	51.6	83.2
April-June	142.4	163.1	57.9	134.5
July-September	30.8	298.2	36.4	94.1
October-December	49.0	211.6	121.7	88.9
<i>1924</i>				
January-March	84.5	126.6	52.3	74.6
April-June	100.0	259.6	74.3	157.3
July-September	34.7	242.5	80.3	75.8
October-December	120.2	239.2	177.2	48.0
<i>YEARLY</i>				
1921	151.9	132.3	131.5	106.8
1922	121.9	210.2	111.2	128.8
1923	73.5	244.0	68.5	100.0
1924	85.5	224.0	106.7	87.8

Our finding may be explained by concentration in the locality of a considerable number of plants in the type of industry from which most of the data had to be drawn. At any rate, the turnover in this class of skilled occupations was high over a considerable period and was measurably higher than the turnover of semi-skilled occupations. In the latter groups, turnover was not uniformly higher than among skilled occupations if both grades are

considered together, though there was a tendency for turnover to vary with skill. In long service groups, turnover was low whether one was comparing skilled mechanics' jobs or unskilled laborers' jobs.

There is no way of saying how much less stability pertains to specialized than to skilled occupations. Much progress must be made in occupational classification before even an adequate study of the subject can be attempted.

CHAPTER VII

TURNOVER OF MEN AND WOMEN

Throughout the chapter dealing with major reasons for leaving, comment was frequently made that plants employing women have more resignations for personal, community and family reasons than plants employing men. On the other hand, discharges for disciplinary reasons are lower for women than for men. On the basis of these statements some analysis seems warranted of the effect upon turnover. To be sure, many of the metal plants are exclusively men's industries. Only seven plants in those reporting continuously employ large numbers of both men and women. From the point of view of the rate of turnover, these concerns may be divided into two groups:

- I. Concerns where the turnover rate for women is regularly higher than for men.
- II. Concerns where the rate is lower for women than for men.

Five of the seven concerns fall in the first group. Monthly turnover rates reduced to an annual basis are plotted for men and women. Firm 1 has a four-year record with scarcely a month when the curve for men reaches as high a point as the curve for women. Not only is the general level of turnover among women higher than among men but fluctuation is more extreme. In Firm 2, the differences between the two curves are less extreme and at several points the curve for women drops lower than the turnover for men. However, in net effect the curve for men maintains the lower rate. In the period of increasing turnover, in 1922 and 1923 at Firm 10, the curve for women rises rapidly and in this rise is usually a month in advance of the curve for men.

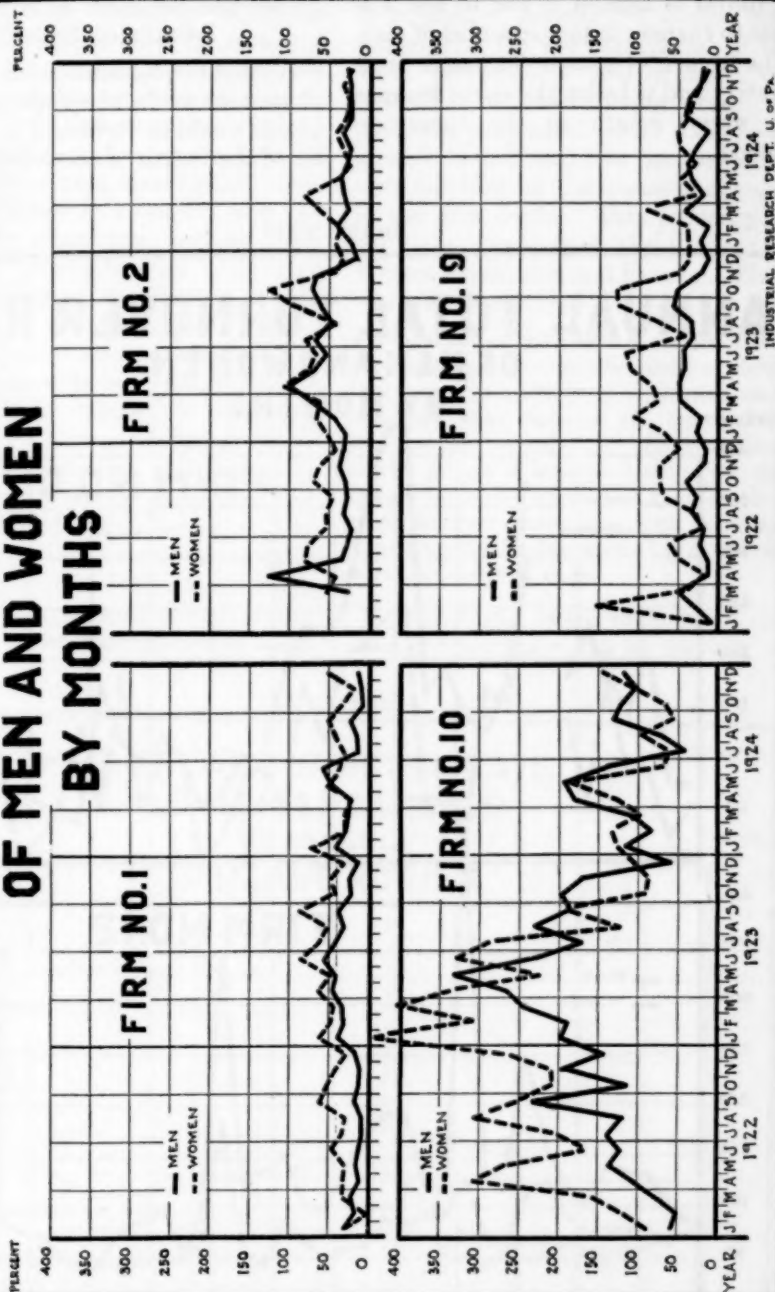
The two curves drop in the same way from the last half of 1923 to the end of 1924. While there are minor points where turnover rates for women are below those for men, the main differences are in the opposite direction. In Firm 19 the rates of change among women are excessive; in some months it is three to five times the rate of change among men. While the extreme fluctuation is in some degree due to the small numbers involved, this will not account for the great contrast between the turnover of men and women. Even though turnover decreased to moderate figures in 1924, the low points reached by the men's curve were rarely approximated by as low rates for women in the same months in the first half of the year. In the second half the rates were almost identical. Despite a few exceptional months, turnover for women towers far above that for men at Firm 17.

Over a stretch of three or four years, then, at these firms, women employes have been less stable than men. More important than the degree of differences in the rates is the further fact that turnover peaks, due to changes among women employes, have been more extreme and fluctuations greater.

Two plants with lower turnover for women than for men employes are shown on Chart XXIII. The experience of one of these plants is surprising, since the basic raw material is metal and women work on many of the lighter operations. The showing of the curves is lower for women and the fluctuations are rarely comparable to the extremes of the curve for men. In general the curves fluctuate at the same time. At Firm 12, in so far as

CHART XIII

ANNUAL TOTAL TURNOVER RATE OF MEN AND WOMEN BY MONTHS

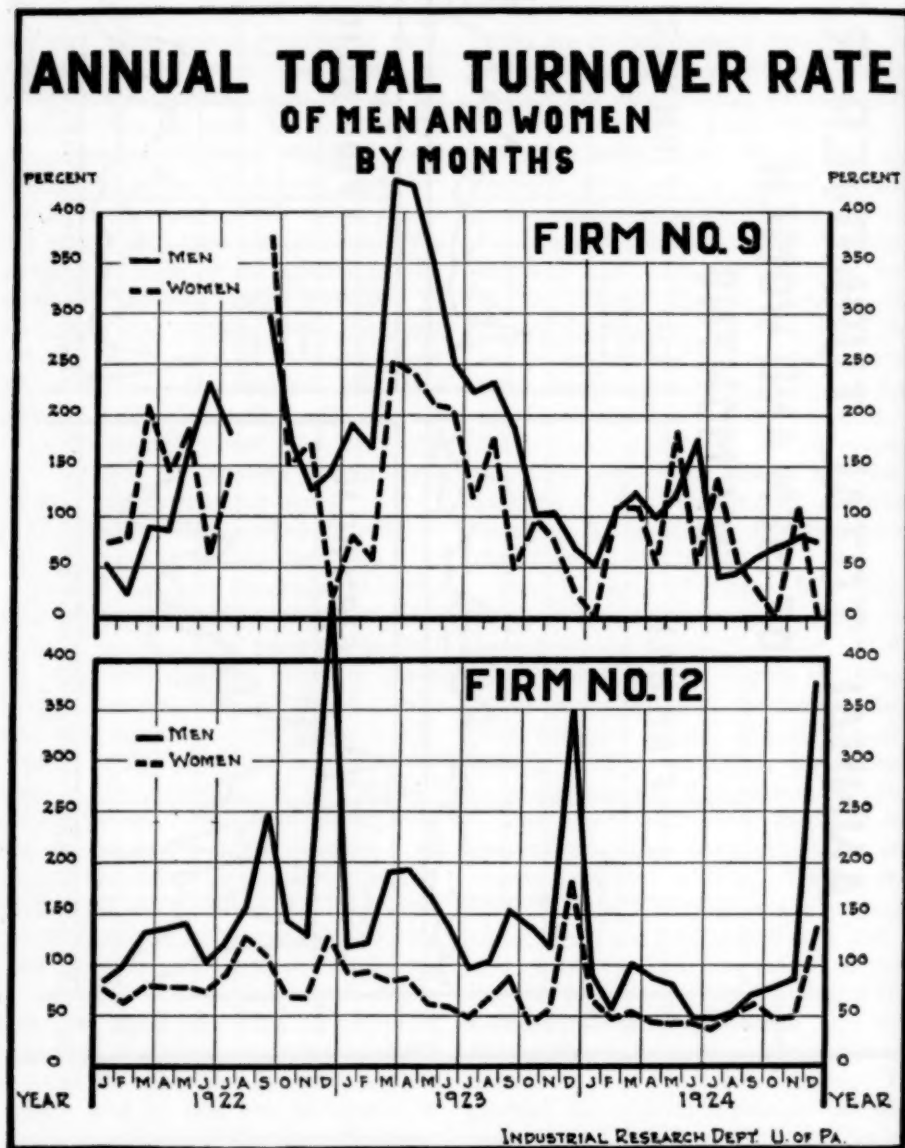


turnover is high, it is fair to say it is due to changes in the personnel of men. The women's turnover fluctuates moderately and is below the curve for men in every month in the three-year period.

TURNOVER OF MEN AND WOMEN BY LENGTH OF SERVICE

A slight qualification to the conclusion drawn for the majority of these plants would be furnished by an analysis of the length of service of men and

CHART XXIII



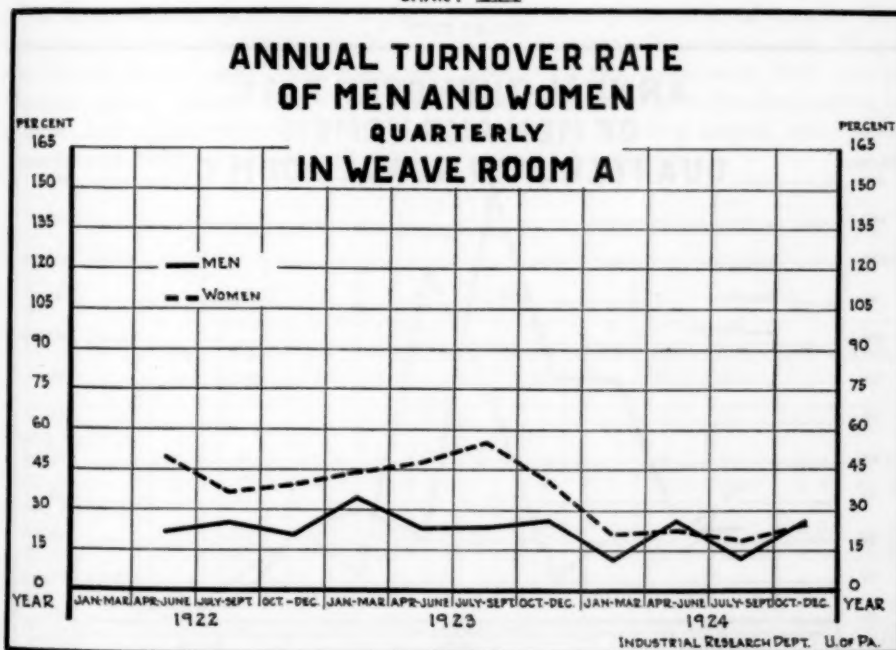
women. While turnover rates for women were higher than for men, the losses among women took place less heavily in the first months of employment. When a longer period, say one year, is taken, the separations of women were in most cases higher. This can be explained in a number of ways. In the first place, men seeking work cannot as frequently wait until they have found the job wanted as can many women applicants. Consequently, they must take one as directly as possible and change when a more desirable opening is available. Besides men's figures are weighted by common laborers—an occupation in which the opportunity for change and the likelihood of change are great. At any rate, if seasonal work were equally adapted to men and women the chances that the first persons hired would remain for three months would seem

to be greater, normally, if women were employed. On the other hand, if the work would last a year or more, the likelihood of losses among women as the work progressed would seem to be greater than if men had been engaged, even allowing for the excess of changes in the first weeks. This tendency in our data agrees with the findings of Messrs. Brissenden and Frankel. Their conclusion was that

a comparison of the length of service of the separated male and female employees shows that larger proportions of separating male employees than females are bunched in short-service periods. In the long-time-service groups of separated employees, the figures for males show that they are less prone to sever connections with an establishment after having worked in it a considerable period of time.¹

Undoubtedly, in the majority of our cases the tendency was for the rate of

CHART XXIV



¹ Brissenden, Paul Frederick and Frankel, Emil—*Labor Turnover in Industry*. Pp. 123-124, 1922.

CHART XXX

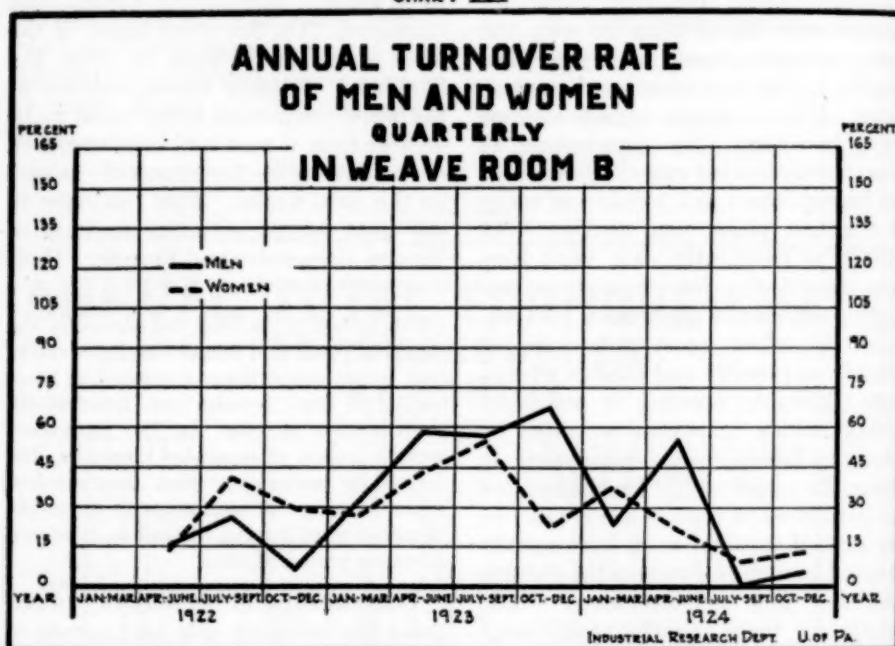
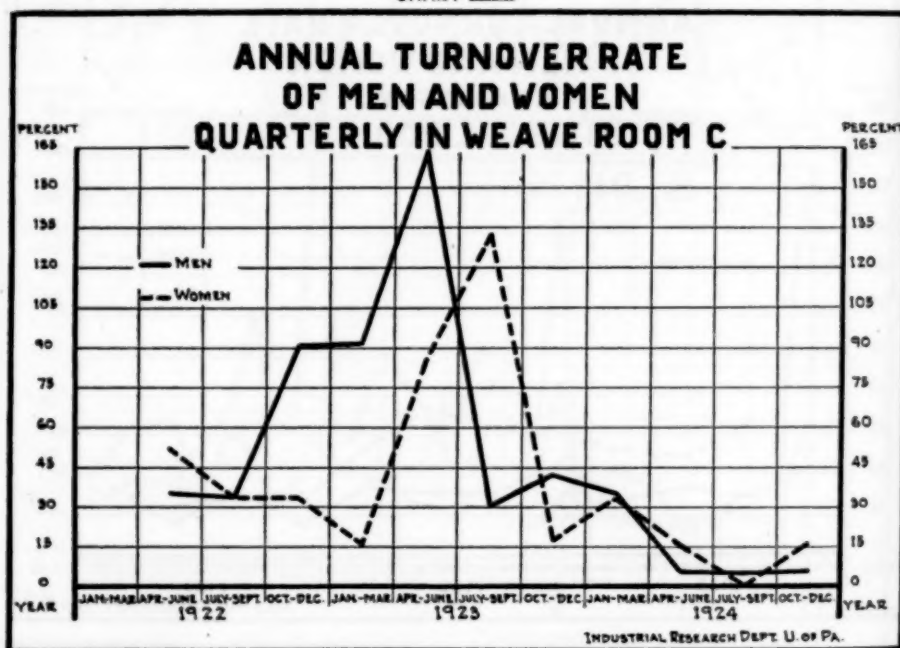


CHART XXXI



turnover of women to exceed that of men. Such a finding fails to convince, since men and women normally are assigned to different operations. Rarely is it possible to compare groups where the occupation, conditions of employment and remuneration are the same. Turnover figures for three weave rooms give a situation where men and women are doing identical work, and are paid the same piece rate under the same working conditions. Of course, there remains the likelihood of differences in age and length of service. If these are disregarded, comparison in rates of turnover is in other respects fair. Since one department is small, rates are figured by quarters instead of by months. In the weave room of plant A, the numbers of men and women are about equal. The turnover curve for women is higher than the curve for men in nine quarters, out of eleven. In two quarters the rate is double that for men.

In Weave Room B of a second plant the proportion of women is a trifle over two-thirds that of men. The curve for women starts about even with the men's, but climbs higher in the last quarters of 1922. In 1923 and in the

second quarter of 1924 the rate of loss is higher among men than women weavers. The end of 1924 shows a low rate for both groups, but with the women's rate above that of men. In this case the evidence is conflicting.

In a third weave room, employing a total of about 100 weavers, men make up only one-fourth of the total. Here turnover is relatively high with rates for men above those for women in six out of eleven quarters.

Quarterly turnover figures are given in the table below:

Summarizing the net differences by years, Weave Room A had an annual loss in 1923 of 26.9 per cent among men and 47.0 among women. In the next year the men's rate amounted to 20 per cent, the women's to 21.5. Weave Room B had a high rate of 53.0 in 1923 among men, against 36 per cent for women. In the next year the rates almost balance, being 20.9 for men and 20.2 for women. The third plant lost 75 per cent in turnover of men in 1923 when the rate for women was 35 per cent. In the next year both groups lost at very low rates, the men having 11 per cent against a higher rate of 16 per cent for women.

TABLE 39

WEAVE ROOM	1922			1923				1924			
	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.
<i>Weave Room A:</i>											
Men.....	21.5	24.7	20.4	34.3	24.2	23.3	25.7	12.1	26.9	12.8	26.9
Women.....	48.9	37.2	39.0	44.0	47.5	54.9	40.8	20.8	22.0	18.0	25.3
<i>Weave Room B:</i>											
Men.....	15.6	26.6	6.3	32.0	58.8	57.1	67.7	23.5	54.5	0.0	5.6
Women.....	13.9	41.4	29.6	26.7	43.5	54.5	22.2	37.2	20.8	9.5	13.2
<i>Weave Room C:</i>											
Men.....	34.3	33.3	90.3	91.4	164.7	30.8	42.1	35.1	5.3	5.2	5.5
Women.....	52.2	33.3	33.3	16.7	87.0	133.3	17.4	33.3	15.4	0.0	16.0

MEN AND WOMEN IN SPECIAL OCCUPATIONS COMPARED RESPECTIVELY WITH MEN AND WOMEN IN ALL OCCUPATIONS

Since the weaving occupations are the most skilled in textile plants, the figures are interesting from the point of view of turnover in skilled and unskilled occupations. An arrangement made to show the proportions of all men and women in these occupations and the proportion of the total turnover due to each group is given below. The comparison here must be understood to be between women weavers and women in other occupations and men weavers and men in other occupations. There is no contrast implied between the figures for men and women.

In 1923 and 1924 men in Weave Room A amounted to 11 per cent of all men employes in the plant. In both years they contributed less than this proportion among separations, even less than half (4.9 per cent) in 1923, and 7.9 in 1924. Women weavers in Room A were 9.2 per cent of the women employed in 1923 and 8.7 in 1924.

Their share in the separations of women was 6.0 and 4.8 in 1923 and 1924 respectively. In the case of both men and women then, the turnover in this skilled occupation was lower than the average in all occupations in the plants. The same statement holds for other weave rooms except in 1922 and 1923, when the extreme turnover in Weave Room C made the proportion of separations higher for men weavers than the proportion of men on the roll. In the same period turnover rates for men and women are given in some other textile operations.

In most other textile processes, men and women perform different work. Men do all mechanical work, and all dye-room work. Women exclusively perform most winding and finishing operations. By contrast with the low turnover of women weavers attention should be given to the comparatively high turnover of women winders. Fifty-six to 61 per cent of all women employed were engaged in winding. These operations caused 65 to 78 per cent of all separations of women in the two years, showing not only a high turnover but a turnover far in excess

TABLE 40

WEAVE ROOM	1922*		1923		1924	
	Proportion of Separations	Proportion of Average on Roll	Proportion of Separations	Proportion of Average on Roll	Proportion of Separations	Proportion of Average on Roll
<i>Weave Room A:</i>						
Men.....	5.6	10.5	4.9	10.8	7.9	11.1
Women.....	5.5	7.7	6.0	9.2	4.8	8.7
<i>Weave Room B:</i>						
Men.....	3.2	7.8	6.5	7.3	5.5	7.4
Women.....	3.7	7.7	4.2	8.4	4.4	8.3
<i>Weave Room C:</i>						
Men.....	4.6	3.7	4.8	3.8	3.2	7.0
Women.....	1.4	2.2	1.0	2.1	1.0	2.3

* 9 months only.

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TABLE 41—ANNUAL TURNOVER RATE BY QUARTERS—MEN AND WOMEN

OCCUPATION	1922			1923				1924			
	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.	Jan.- Mar.	Apr.- June	July- Sept.	Oct.- Dec.
<i>Beaming:</i>											
Men.....	6.9	22.6	0.0	30.8	60.4	22.2	0.0	0.0	0.0	0.0	15.4
Women.....	14.3	14.3	28.6	61.5	46.2	28.6	66.6	16.0	16.7	52.2	0.0
<i>Burling:</i>											
Men.....	85.7	80.0	75.0	111.1	320.0	114.3	85.7	0.0	85.7	123.1	26.7
Women.....	14.3	14.8	114.2	41.4	77.4	11.8	58.8	25.0	38.7	93.3	20.0
<i>Dyeing:</i>											
Men.....	68.5	10.5	44.4	32.4	55.6	36.4	25.0	0.0	25.0	13.8	36.4
<i>Finishing:</i>											
Men.....	0.0	28.6	0.0	0.0	57.1	50.0	28.6	200.0	80.0	75.0	47.1
Women.....	0.0	72.7	0.0	66.7	66.7	85.7	28.6	0.0	0.0	0.0	0.0
<i>Mechanical:</i>											
Men.....	92.9	13.6	7.0	7.1	21.4	6.9	38.7	26.7	14.3	14.5	7.7
<i>Special Finishing:</i>											
Men.....	78.3	39.2	64.0	47.1	73.5	17.4	0.0	0.0	18.2	30.0	9.8
Women.....	36.4	0.0	36.4	33.3	0.0	0.0	0.0	0.0	0.0	33.3	0.0
<i>Winding:</i>											
Women.....	95.7	62.1	71.9	70.6	92.9	86.0	88.6	51.1	59.5	35.5	30.7

TABLE 42

OCCUPATIONS	1922*		1923		1924	
	Proportion of Separations	Proportion of No. on Roll	Proportion of Separations	Proportion of No. on Roll	Proportion of Separations	Proportion of No. on Roll
<i>Beaming:</i>						
Men.....	1.4	6.1	2.6	5.7	0.8	6.0
Women.....	0.8	2.5	1.7	2.4	1.2	2.2
<i>Burling:</i>						
Men.....	3.2	1.6	4.2	1.5	3.2	1.6
Women.....	2.0	2.5	1.9	2.9	3.4	3.1
<i>Dyeing:</i>						
Men.....	3.9	3.9	2.3	3.6	2.4	3.4
<i>Finishing:</i>						
Men.....	0.4	0.5	0.9	1.6	6.3	1.9
Women.....	0.4	0.4	1.0	1.2	0.0	1.2
<i>Mechanical:</i>						
Men.....	5.6	6.2	2.1	6.0	3.6	6.2
<i>Special Finishing:</i>						
Men.....	7.7	5.3	3.0	4.9	2.4	4.7
Women.....	0.4	1.0	0.1	1.0	0.2	1.3
<i>Winding:</i>						
Women.....	78.3	60.5	68.3	58.6	64.7	56.4

* 9 months only.

of the proportion of these occupations in women's work in the plant.

The highest annual turnover rate for women weavers was 47 per cent in Weave Room A in 1923. In the same year winders had a rate of 84 per cent. In the next year when women weavers had a rate of separations of 21.5, winders rated at 44. Stated approximately, then, the loss among winders amounts to double that among women weavers.

The proportion of separations by comparison with the proportions in the active force shows that there is no other important process where the relative loss of women is greater than the ratio involved in the active force.

In mechanical occupations the turnover rates for men were very low in all quarters except the second of 1922. In four quarters the figure was only 7 per cent. The annual rates in 1923 and 1924 were 21 and 16 respectively. Though 6 per cent of all men in the

plant were engaged in mechanical trades, their turnover caused only 2 to 3½ per cent of men's separations in 1923 and 1924. A slightly higher figure of 37 and 19 per cent in the different years was found among dye-room workers.

The high turnover for women is due to the losses among winders, an occupation in which nearly two-thirds of all women are employed. The rates for women in finishing operations are moderate. Rates for men are not only lower than women's rates for the whole plant, but tend to be at least as low on weaving. When one compares men and women of equal skill working under the same conditions, the low turnover rate tends to be as often in favor of the women as of the men. The low rates of men on mechanical and other skilled operations make up for some weighing of high rates on trucking and miscellaneous maintenance work.

CHAPTER VIII

INFLUENCE OF NATIONALITY UPON LABOR TURNOVER

No conclusions should be drawn concerning turnover by nationality unless analysis is made of occupations held and other conditions of employment. Unskilled occupations generally are more subject to changes than skilled. In many of the reporting plants, a high proportion of the employees were born in the United States. One paper company has 96.2 per cent of its roll in this group, with 2.6 Germans, and the remaining 1.2 per cent divided among many nationalities. A higher proportion of non-native-born is found in most metal plants. Yet the distribution is unlikely to include any large number of national groups. One plant with 68 per cent of its roll born in the United States has 23 per cent Polish workers, but has them on special occupations with little chance for comparisons. In another plant with 80.5 per cent native-born, 11.6 come from the British Empire, and the only other important group is 4.5 per cent of German skilled workmen. In some other plants where separations data are available, the audit of rolls has not been maintained over a long period. For one large firm, data are available by occupations and national groups.

In the figures in Table 43 Italians have a higher discharge rate in every year than any other large national group. Discharges for Russians were nearly as high as for Italians in 1922, but were below the average for the plant in other years. Lay offs were highest among Russians in 1922, if one disregards the miscellaneous group covering many nationalities. In 1923 and 1924, lay offs were high for Italian, Canadian, Polish and Russian workers, in the order named. Voluntary terminations tend to be high in every year for Italians and Russians. In total

turnover rates Italians and Russians are highest in every year with Polish ranking next in two years and above the average for the plant in the third year. The lowest total turnover rates were for English, Germans and Irish in 1922, Irish, Germans and Scandinavians in 1923 and 1924.

Americans constituted from 66 per cent to 72 per cent of the payroll in the various years. Over the period the tendency was for their proportion to decrease. In two years they contributed less than this proportion to the separations, and in the third year the proportion of separations slightly overbalanced the proportionate ranking on the rolls. It is evident that new hirings were increasing the non-native group more largely than the American. In all years Italians, Poles and Russians had larger proportions of the terminations than they formed of employees in the plant. In 1923, when the turnover increased for nearly all groups, that for Austrians, Irish, Germans and Scandinavians decreased. In 1924, the turnover for the plant was 78, or a trifle over one-half the rate of 1923. In this year Italian and Russian nationals were the only groups with a rate above 100 per cent. Irish, Germans, and Scandinavians were below the average for the plant with rates ranging from 48 to 57; other nationals ranged from 60 to 92. In two years turnover rates of native-born workers were below the average for the plant, in the third year 1 per cent higher.

MAIN DIVISIONS OF TURNOVER BY NATIONALITY

When the causes for separation are considered, a partial explanation for the wide differences between nationalities is secured. The range between

TABLE 43—YEARLY TURNOVER RATES OF NATIONALITY BY MAIN DIVISIONS, 1922-1924

NATIONALITY	1922					1923					1924				
	Total	Resignation	Discharge	Lay Offs		Total	Resignation	Discharge	Lay Offs		Total	Resignation	Discharge	Lay Offs	
United States.....	109.8	70.9	5.0	33.9		147.4	66.5	14.8	66.1		70.5	27.5	8.6	34.4	
Italy.....	149.8	97.2	9.2	42.9		257.9	84.2	29.0	144.7		188.5	47.7	23.9	116.9	
Poland.....	142.9	97.2	7.0	38.7		164.6	51.3	16.5	96.8		82.1	14.6	4.7	62.8	
Austria.....	138.8	88.8	6.1	43.9		100.0	37.9	6.8	55.3		78.4	22.4	7.7	48.3	
England.....	92.6	65.2	2.1	25.3		106.7	42.2	4.5	60.0		60.7	29.2	3.4	28.1	
Ireland.....	93.4	55.4	5.4	32.6		91.0	43.8	9.0	38.2		47.8	18.5	6.5	22.8	
Germany.....	82.2	50.0	1.6	30.6		62.3	37.7	21.3	3.3		55.1	24.6	4.4	26.1	
Russia.....	158.0	94.0	10.0	54.0		190.2	90.2	9.8	90.2		103.7	32.1	7.4	64.2	
Denmark, Norway and Sweden.....	104.2	80.8	2.1	21.3		97.8	45.7	8.7	43.4		59.2	28.6	10.2	20.4	
Scotland.....	129.5	90.9	4.5	34.1		153.0	71.2	13.6	68.2		92.4	24.1	6.3	62.0	
Canada.....	133.3	113.3	.....	20.0		138.6	23.1	7.7	107.7		85.7	28.6	.....	57.1	
All others.....	288.6	171.4	14.3	102.9		145.3	71.7	5.7	67.9		91.3	26.3	12.5	52.5	
Total.....	1115.9	75.1	5.4	35.4		146.4	63.4	14.0	69.0		77.5	27.0	8.6	41.9	

groups in the resignation percentages is not nearly so large as in the total turnover figures. In every year resignation rates for Italians and Russians are higher than the average for the plant. This is not true of Polish and Austrian employees; while the resignation rate was high in 1922, it fell below the average for the plant in 1923 and 1924, and far below the rates for those years for workers born in the United States. The groups with lowest and highest resignation rates are shown below.

While Germany appears in the low group every year and Italy in the high group, it will be seen that countries low one year become outstandingly high in

others, indicating that occupation or some other factor must be taken into consideration as well as nationality in accounting for stability.

In every year lay offs for Italians, Russians and Poles were above the average rate for the plant, while the number of English, Germans and Scandinavians were not reduced as heavily by lay offs.

Since the turnover percentages are based upon the separations and the number on the roll within each nationality group, the figures give no idea of the number of employes in the group affected by high turnover.

The proportion of separations attri-

GROUPS WITH LOWEST RESIGNATION RATES			GROUPS WITH HIGHEST RESIGNATION RATES		
1922	1923	1924	1922	1923	1924
Germany Ireland England United States	Canada Germany Austria England	Poland Ireland Scotland Germany	All others Canada Italy Poland	Russia Italy All Others Scotland	Italy Russia England Canada

TABLE 44—PROPORTION OF SEPARATIONS AND NUMBER ON PAYROLL BY NATIONALITY

NATIONALITY	1922		1923		1924	
	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll	Proportion of Separations	Proportion of No. on Payroll
United States.....	68.5	72.2	70.8	70.3	59.6	65.5
Italy.....	6.2	4.8	7.0	4.0	10.8	4.4
Poland.....	5.8	4.8	6.2	5.5	7.7	7.2
Austria.....	4.0	3.3	2.4	3.6	4.0	4.0
England.....	2.5	3.2	2.3	3.1	2.4	3.0
Ireland.....	2.6	3.1	1.9	3.1	1.9	3.1
Germany.....	1.6	2.1	0.9	2.1	1.7	2.4
Russia.....	2.4	1.7	2.8	2.1	3.7	2.8
Denmark, Norway and Sweden....	1.4	1.6	1.1	1.6	1.3	1.7
Scotland.....	1.6	1.5	2.4	2.3	3.2	2.7
Canada.....	0.5	0.5	0.4	0.5	0.5	0.5
All others.....	2.9	1.2	1.8	1.8	3.2	2.7
Total.....	100.0	100.0	100.0	100.0	100.0	100.0

butable to each national group is given in the table preceding, in connection with the proportion that each constitutes of the total payroll. Analysis of the active force shows that two-thirds or more of the employes were born in the United States. Poles and Italians are next in numerical importance. In 1922 and 1924, the native-born employes contributed a smaller proportion to the separations than they constituted of the total force. In 1923 the proportions nearly balance. In every year Italians contributed more largely to the turnover than their ratio in the working force. This is especially marked in 1924, when the proportion of Italian separations is nearly two and one-half times the proportional distribution for the active force. The separation percentage of Polish employes is only slightly higher than their proportions on the roll, while that of Austrians is about evenly balanced in 1924, higher in 1922 and lower in 1923. These four nationalities account for about 81 to 85 per cent of the roll. Other nationalities ranging each from 1 to 3 per cent of the total force normally contribute an equal or smaller proportion to the turnover than their percentage of the force with one or two exceptions, notably Russia.

One can say without hesitation that certain nationalities are regularly and fairly continuously causing a higher turnover than others, but one cannot, without analyses of occupational rank, attribute this to national aptitudes. Is it perchance due to disadvantages in the trades open to, or jobs filled by these groups?

The only answer possible to the query is furnished in this study by comparing the separations of different nationalities according to the rank of skill of occupations held. The classification described in the chapter on occupations is followed here. These data are avail-

able for two years, 1923 and 1924. In 1923, when turnover for all skilled A occupations was 72, that for Italy and Russia amounted to nearly 156, Scotland was third highest and Scandinavia fourth. The lowest figures were for Canada, Austria and Germany, with the United States' percentage also considerably below the average for all skilled. In 1924 Russia was markedly lower than in the previous year, but Italy appeared again in the highest place. Austria, Ireland and Scandinavia were especially low.

When the whole payroll is considered, Italians and Poles ranked next to Americans in numerical importance. When the skilled A group on Table 46 is considered, a wholly different distribution is found: Scottish, English, Irish and German stand next to Americans in number in skilled trades. While 2.3 to 2.7 per cent of the whole force were Scotch, in the skilled trades they were 5.5 to 6.4 per cent of the total. Polish and Italian workers hold relatively few of the skilled jobs. In the semi-skilled occupations, Poles were next to Americans, filling 12 to 14 per cent of all semi-skilled positions though they were less than half this percentage in the total force. Austrians, Russians and Italians constitute important numbers in semi-skilled occupations. In fact, 32.0 per cent of all semi-skilled positions were filled by workers born in one of the four countries, whereas they held only about 6 per cent of the skilled A occupations. With the predominance of Americans on the roll, it would be certain that they would far outnumber others in every grade of skill. It is not easy to account for their apparent avoidance of semi-skilled jobs, when there is no proportionate scarcity in the unskilled. It is significant that in these semi-skilled occupations Italians have a lower rate of turnover in both years than in the skilled jobs; it

TABLE 45.—YEARLY TURNOVER RATES OF NATIONALITY BY OCCUPATIONAL GROUPS AT ONE LARGE CONCERN, 1923-1924

NATIONALITY	1923—RATE OF TURNOVER—1923						1924—RATE OF TURNOVER—1924					
	Skilled A	Skilled B	Semi-skilled	Unskilled	Clerical and Minor Ex.	Total	Skilled A	Skilled B	Semi-skilled	Unskilled	Clerical and Minor Ex.	Total
United States.....	68.2	139.2	114.0	294.9	36.0	147.4	30.1	88.3	56.5	159.8	13.5	70.5
Italy.....	155.6	277.8	155.1	406.8	0.0	257.9	114.3	214.3	107.0	247.9	0.0	188.5
Poland.....	71.4	233.3	136.4	232.1	....	164.6	91.6	150.0	63.7	130.2	50.0	82.1
Austria.....	42.9	212.5	83.9	213.3	10.0	100.0	18.8	235.7	47.8	177.8	50.0	78.4
England.....	69.4	150.0	107.1	229.4	33.3	106.7	45.0	120.0	62.5	133.3	0.0	60.7
Ireland.....	73.3	50.0	89.5	128.6	50.0	91.0	25.0	66.7	77.8	61.8	0.0	47.8
Germany.....	46.2	100.0	90.0	100.0	0.0	62.3	31.3	100.0	45.5	146.2	0.0	55.1
Russia.....	155.6	166.7	145.2	357.1	50.0	190.2	37.5	133.3	95.6	157.1	25.0	103.7
Denmark, Norway and Sweden.....	77.8	150.0	78.6	350.0	0.0	97.8	27.3	42.9	157.1	114.3	16.7	59.2
Scotland.....	125.0	225.0	....	176.9	33.3	153.0	50.0	150.0	160.0	216.7	20.0	92.4
Canada.....	40.0	....	133.3	....	0.0	138.5	0.0	....	350.0	166.7	0.0	85.7
All others.....	61.5	142.9	140.0	256.3	57.1	145.3	66.7	43.5	62.5	163.0	33.3	91.3
Total.....	72.4	149.3	119.0	284.7	34.0	146.4	32.8	99.5	64.6	161.4	13.7	77.5

TABLE 46.—PROPORTION OF SEPARATIONS AND AVERAGE NUMBER ON PAYROLL BY NATIONALITY AND MAJOR OCCUPATIONAL GROUPS AT ONE LARGE CONCERN, 1923-1924

[illegible]

TABLE 47—PROPORTION OF YEARLY SEPARATIONS BY NATIONALITY ACCUMULATED ACCORDING TO LENGTH OF SERVICE

LENGTH OF SERVICE	NATIONALITY											
	United States	Italy	Poland	Austria	England	Ireland	Germany	Russia	Scandinavia	Scotland	Canada	Total
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<i>1922</i>												
Under 1 month.....	19.9	39.5	26.3	23.6	13.1	17.2	13.2	27.1	13.1	22.6	5.6	20.1
Under 3 months.....	34.5	60.9	49.0	39.9	29.7	27.5	18.9	40.7	21.8	30.2	22.2	35.5
Under 1 year.....	45.7	69.5	69.7	54.7	39.3	37.8	22.7	60.5	47.9	45.3	53.5	48.2
<i>1923</i>												
Under 1 month.....	41.0	39.7	39.3	29.1	24.0	27.2	42.1	49.1	33.4	33.7	33.3	40.0
Under 3 months.....	67.0	69.4	65.4	59.2	59.4	56.8	60.5	77.6	60.1	72.3	72.2	66.9
Under 1 year.....	85.9	92.5	88.5	84.4	82.3	77.8	79.0	91.4	82.3	97.0	88.9	86.5
<i>1924</i>												
Under 1 month.....	25.6	28.2	20.1	24.2	20.4	9.1	13.2	21.4	13.8	16.4	16.7	23.9
Under 3 months.....	55.1	64.5	46.5	48.4	48.2	43.2	47.4	50.0	41.4	42.4	75.0	54.2
Under 1 year.....	86.3	95.1	90.7	84.6	74.2	79.5	86.9	94.1	72.4	89.0	100.0	87.5

is also significant that despite the high turnover for the plant among this nationality, they rank lower on semi-skilled jobs than some other national groups with a lower turnover average for the plant.

NATIONALITY BY LENGTH OF SERVICE

Length of service of all groups in the plant tended to be shorter among separated employees in 1923 than in 1922, with a shift to longer service in 1924. The percentage of those born in the United States and on the roll less than one month was a trifle lower than the average for the plant in 1922, and higher in the two following years. In this interval, Italians were above the average for the plant in two years. There is no group above the average for the plant in this interval in every year. English, Irish, Scandinavian and Scottish were below the average for the plant in the less-than-one-month group in all years—groups employed mainly in skilled occupations. The range in percentages leaving under three months is greater, only 19 per cent of Germans having left in this interval as opposed to 61 per cent of Italians in 1922. The shorter records of 1923 show a range from 57 per cent by Irish to 69 per cent by Italians. When the proportions are

accumulated for all separations under one year, Italians and Poles are above the average of the plant in every year, Americans a trifle, though not a significant amount, below the average, while Austrians, English, Irish, Germans and Scandinavians are below the average for the plant in every year. The nationalities with shorter service than the plant average are, then, those found largely in unskilled trades. The differences from year to year brought about by interrupted operation are more dominating in the comparison than the national differences.

No conclusions concerning stability can be drawn without careful classification of the occupations involved. Even with such a grouping of occupations as here made by grade of skill, there still are differences in the agreeableness of jobs within any group and a high proportion of disadvantageous trades may easily fall to some one nationality. Though Austrian workers are a very stable group in the skilled A occupations, the turnover for the plant would be excessive if skilled B jobs were subject to a rate of change comparable to the changes on such jobs by this nationality in the past two years. The main value of this analysis is furnished by the distribution of nationality according to occupation.

CHAPTER IX

THE RELATION OF EDUCATION TO LABOR STABILITY

Little has been written on the relation of education to labor stability. Firms have specifications giving the minimum education requisite for certain jobs. There are also some practical conclusions among personnel managers regarding jobs on which high school students will not stay for any considerable time. All this unco-ordinated experience helps, no doubt, to certain standards in selection and placement. In the main, however, the educational standard in skilled jobs cannot be determined by any employment organization for its particular plant. The positions must be filled by skilled workers attracted to the trade half a generation ago and, with the exception of standards for a few apprentices, the choice is limited by all the forces that make for selection within the particular trade. To draw any conclusions from separations, then, one must know also the educational attainment of employees in the active force.

Even then no careful analysis of the influence of education upon labor stability can be made until firms change the form in which such information is recorded. The best data for workers trained in schools in the United States would be the age at leaving school and the grade attained at the time of leaving. Lacking such a record a substitute had to be used. Employees who cannot read and write in any language are classed as "No Education." Those who did not go beyond the sixth grade are classed as "Common School." The grammar school group may be regarded in the main as having completed the training, but there is no way of separating those who failed in final years from those who finished. The same is

true of high school; the members of the group have had varying lengths of time in high school, but may or may not have graduated. The same may be said of general college and engineering, though these employes are in the main graduates.

Analyses based on this grouping are bound to be inadequate. They are attempted in the hope of raising questions rather than of reaching conclusions.

Turnover percentages by main divisions are shown on Table 48 for three years—1922 to 1924. Barring the college and engineering groups where numbers are small and turnover tends to be much influenced by reduction of forces, the high school group maintained the highest rates in each of the three years. This ranking persisted when the general level for the plant tended to be high in 1923 as well as in 1924, when the turnover was only a trifle over half that of the previous year. This is especially disconcerting in 1924 when lay offs were higher for each of the other educational groups. For 1922 the common school group had a rate higher than that of the grammar school, but changed to a lower rate for 1923. For 1924 these groups were similar if totals are considered, but voluntary terminations were higher for the grammar school group. For these two groups then figures are inconclusive.

When resignations are considered, employes with high school training stand highest in each year, while the small group classed under "No Education" are lowest in every year in resignations as well as in total turnover. It is important, then, to determine what proportion of the working force is found

TABLE 48—YEARLY TURNOVER RATES OF EDUCATIONAL GROUPS BY MAIN DIVISIONS AT ONE LARGE CONCERN

EDUCATION	1922				1923				1924			
	Total	Resig- nations	Dis- charges	Lay Offs	Total	Resig- nations	Dis- charges	Lay Offs	Total	Resig- nations	Dis- charges	Lay Offs
Noeducation.....	92.9	64.1	4.2	24.6	109.4	35.8	10.7	62.9	64.9	13.3	8.5	43.1
Common school.....	127.0	82.4	5.5	39.1	129.8	52.2	11.2	66.4	76.2	18.0	7.8	50.4
Grammar school.....	111.2	71.5	5.3	34.4	148.2	63.6	14.6	70.0	77.7	28.3	8.8	40.6
High school.....	140.9	93.8	5.7	41.4	187.5	102.8	17.1	67.6	85.8	45.1	8.8	31.9
General college.....	277.8	200.0	11.1	66.7	216.7	116.7	0.0	100.0	172.7	136.3	18.2	18.2
Engineering and technical.....	200.0	150.0	0.0	50.0	100.0	50.0	0.0	50.0	25.0	25.0	0.0	0.0
Total.....	115.9	75.1	5.4	35.4	146.4	63.4	14.0	69.0	77.5	27.0	8.6	41.9

in each of these groups. For this purpose tabulation is made in somewhat different form. All separations are considered as 100 and the proportion of separations in each of the education classes given by years beside the proportion of each class in the working force.

This table (Table 49) shows that, despite their high turnover, high school employees constituted a small part of the working force, at most 7 to 7.7 per cent. With the high turnover and reduction in the total roll they decreased each year considered. However, though they were but 7.7 per cent of the roll in 1922, they contributed 9.2 per cent of the turnover and in the next year 9.6 per cent of the turnover out of 7.5 per cent of the working force. The no education group in every year and the common school in two years, contributed a smaller proportion to separations than they were of the total payroll. The proportion of separations was a trifle less for grammar school in 1922 than the proportion on the roll, though about the same ratio in the last two years. Since more than two-thirds of all employees fall in the grammar school group, causes of turnover in this group would be of major importance in a period of more active production. There is, of course, no warrant for concluding that stability would be correlated to education similarly in a period of less readjustment. It is quite possible that the greater ease with which high school trained employees could find employment elsewhere would lead to anticipation of lay offs in this period and account for the high rate of resignations already noted.

The major causes for leaving are arranged in the same way as on the previous table.

A measurably more important question than that raised by the turnover among different educational classes is in the occupations filled by these

TABLE 49

EDUCATION	1922		1923		1924	
	Proportion of Separations	Proportion of Active Working Force	Proportion of Separations	Proportion of Active Working Force	Proportion of Separations	Proportion of Active Working Force
No education	3.8	4.8	4.1	5.5	5.4	6.4
Common school . . .	18.1	16.5	13.8	15.5	18.5	18.8
Grammar school . .	67.8	70.5	71.8	70.9	67.5	67.3
High school	9.2	7.7	9.6	7.5	7.7	7.0
General college . . .	0.7	0.3	0.6	0.4	0.8	0.4
Engineering	0.4	0.2	0.1	0.2	0.1	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

groups. Accordingly, tables are shown for each year giving the proportion of educational groups by grade of skill. At the right of each table appears an analysis according to the distribution of the active working force. The classification of skill corresponds with that used in the chapter on occupations. It will be seen that the proportion of high school was highest in the skilled A and clerical grades; grammar school in the skilled A and B, common school in the semi-skilled and no education in the unskilled and semi-skilled. It should be noted that there are a few without any formal school training even in the skilled and shop clerical groups.

Grammar school had the greatest numerical importance for every rank of skill. Considering the skilled A group, it will be seen that the proportion of separations in the grammar school group is about the same as the distribution on the payrolls. In 1923 the loss in the common school group is less by half that of the proportion enrolled. In this grade of skill there is no marked tendency for excessive loss in a particular group except the high school of which the separations are higher every year than their respective proportion on the roll.

The skilled B group is made up of a smaller proportion of high school and a

TABLE 50

[illegible]

TABLE 51—EDUCATION BY OCCUPATIONAL GROUPS AT ONE LARGE CONCERN, 1922-1924

[illegible]

higher proportion of common school. Even in this grade of skill there is no marked divergence between the proportions on the roll and the proportions of separations. The tendency for high school groups to be most prone to change is evident in figures for 1922 and 1923, but is not true in 1924.

When semi-skilled occupations are considered, about one-third of the force are found to be below the grades of grammar school. There is no decided tendency for educational status to be higher in this than in the unskilled oc-

cupations. However, there is a definite tendency for grammar school students to be more stable on semi-skilled than on unskilled jobs.

The interest in this analysis really centers upon the distribution of education according to skill rather than on the light that is thrown upon causes for instability. So few data are available on educational attainment in different trades that a distribution carried over a number of years seems worth while even though the present findings are inconclusive.

CHAPTER X

RELATION OF AGE TO LABOR TURNOVER

Without detailed statistical work it is rarely possible to determine the relation of age to rate of separation. While most firms record on the application blank the age of employes, unless the year of birth is given one cannot be certain that changes have been made at times of re-employment. Besides the number employed in each age group must be ascertained and the record kept up to date. An audit is normally necessary to secure figures showing the age distribution of the working force at any one time. Such audits have been continued for three years for one large concern. Similar records started in some other firms have not been continued long enough to warrant publication of results at this time.

The data in Table 52 for one firm point to some very disconcerting conclusions. Comparison is made of the ratio of separations to numbers employed according to age at the time of leaving. Age intervals vary by five years.

In the year 1922, the highest separation percentages occur among employes 25 to 30 years of age. Among the younger groups, the interval 20 to 25 years was next highest if one considers the total separations, but this figure was caused by a relatively high lay off among younger men. From the point of view of the plant, the separations of men 45 to 50 years was next in importance to that of the 25-to-30-years group, since resignations are especially high in these intervals. For men 50 years and over, a group that comprises one-fifth of all employes, turnover was negligible. Next to this permanent group of older employes those under 20 years had the lowest rate for resigna-

tions, but the highest for discharges and lay offs. Why were employes between 40 and 45 years more satisfied to remain at work than those 45 to 50? Is there a partial explanation in the high lay offs in the latter group?

In the following year the age distribution was very different. The highest figure is for employes under 20 years. Turnover decreases as the higher age groups are reached. Above 35 years of age the only groups showing as much turnover as in the previous year are the 50-year-and-over with a separations rate of 40, and the 40-and-under-45 with an increase from 96 to 98.

When the main divisions of turnover are considered, resignations are found to be lower for employes under 20 than for those of 20-25 years, though the discharges and lay offs are very high for the younger group. The year 1924 resembles 1922 in that the 20-25 and 25-30 groups have the highest turnover. Not only is this true of the total turnover, but when the main divisions of turnover are considered, resignations, discharges and lay offs are all higher for these age intervals than for others.

Table 52 gives the proportion of turnover in each age group by contrast with the proportion on the roll (P. 124).

In 1922 all groups under 40 caused a higher percentage of the separations than they constituted of the total working force, but of these age groups that under 20 is the only one contributing a lower percentage to resignations than they constituted of the working force. The 40-and-under-45-years group, made up of less than 13 per cent of the working force, had more than 18 per cent of the resignations. In 1923 about one-sixth of the working force

TABLE 52

Age	1922				1923				1924			
	Total	Resig- nations	Dis- charges	Lay Offs	Total	Resig- nations	Dis- charges	Lay Offs	Total	Resig- nations	Dis- charges	Lay Offs
Under 20 yrs.....	130.7	60.6	14.2	55.9	386.8	131.8	54.2	200.8	82.6	25.6	8.7	48.3
20 yrs. and under 25 yrs.....	166.8	104.4	9.6	52.8	330.6	142.6	35.8	152.2	175.6	54.0	25.9	95.7
25 yrs. " " 30 yrs.....	184.2	120.8	8.2	55.2	204.6	86.6	18.6	99.4	117.8	47.9	11.2	58.7
30 yrs. " " 35 yrs.....	134.8	88.2	5.9	40.7	159.6	71.8	12.7	69.1	89.7	35.2	7.4	47.1
35 yrs. " " 40 yrs.....	131.3	88.5	4.5	38.3	109.1	51.7	8.0	49.4	75.7	24.0	7.9	43.8
40 yrs. " " 45 yrs.....	95.6	61.0	4.9	29.7	98.1	44.6	8.1	45.4	54.3	18.4	6.1	29.8
45 yrs. " " 50 yrs.....	169.7	118.7	5.0	46.0	76.9	32.7	5.1	39.1	96.0	12.7	4.5	18.8
50 yrs. and over.....	3.0	2.2	0.0	0.8	40.2	19.7	3.0	17.5	25.1	8.6	2.5	14.0
Unknown.....	....	....	....	....	....	....	....	....	25.1	25.1	....	....
Total.....	115.9	75.1	5.4	35.4	146.4	63.5	14.0	68.9	77.5	27.0	8.6	41.9

TABLE 53—PROPORTION OF SEPARATIONS AND AVERAGE NUMBER ON ROLL BY AGE GROUPS

AGE	1921	1922		1923		1924	
	Proportion of Separations	Proportion of Separations	Proportion of Average No. on Roll	Proportion of Separations	Proportion of Average No. on Roll	Proportion of Separations	Proportion of Average No. on Roll
Under 20 yrs.	5.6	5.4	4.3	11.8	4.5	6.2	5.9
20 yrs. and under 25 yrs.	16.9	15.8	10.9	26.9	11.9	25.4	11.2
25 yrs. " " 30 yrs.	20.5	19.0	12.0	16.7	12.0	18.1	11.9
30 yrs. " " 35 yrs.	16.6	16.6	14.3	14.6	13.9	16.5	14.3
35 yrs. " " 40 yrs.	13.8	15.3	13.6	10.0	13.4	13.5	13.8
40 yrs. " " 45 yrs.	9.6	10.8	13.1	8.6	12.8	9.0	12.8
45 yrs. " " 50 yrs.	7.6	16.5	11.6	5.7	10.8	5.0	10.7
50 yrs. and over.	9.4	0.5	20.2	5.7	20.6	6.2	19.3
Unknown.	0.0	0.1	0.0	0.0	0.1	0.1	0.1
Total.	100.0	100.0	100.0	100.0	100.0	100.0	100.0

were under 25 years. This group caused a trifle over one-third of the resignations and nearly one-half of all discharges. Even granting that the lay offs and discharges reflect the business inactivity of the period, it is safe to conclude for this firm that employees over 35 will change employment less rapidly than younger groups. It is not safe to draw the further conclusion that instability will decrease as age decreases. The groups from 20 to 30 contribute very largely to resignations and discharges. In 1922 and 1924 a trifle more than 40 per cent of the separations were less than 30 years of age, whereas 55 per cent in 1923 and 50 per cent in 1924 had not reached 30 years. Stated differently, employees under 30 years made up 27 to 29 per cent of the payroll by contrast with 40 and 50 per cent of the separations. Considering all employees under 40 years, one finds 55 per cent of the payroll by contrast with 72 and 80 per cent of the separations in 1922 and 1923. About 45 per cent of the working force had attained 40 years or over. These age groups

caused only 28 per cent of the separations in 1922 and 20 per cent in 1923 and 1924.

There is a marked increase in turnover percentages in 1923 over 1922, in all age intervals except 45-and-under-50, for which the percentage decreases to about one-half the 1922 figure, and 35-and-under-40 with 22 per cent less. The number of employees leaving a plant in any age group will be influenced by the separations caused at the initiative of the employer. When only resignations are considered, one gets more nearly the proportion dependent upon the preference of employees. In resignations in 1922 the 25-and-under-30-years group ranked highest, 45-and-under-50 next highest, and 20-and-under-25 had third place; in 1923, the 20-and-under-25 group had the highest resignation ratio, under-20-years the next highest, and 25-and-under-30 held third place. In 1924 the 20-and-under-25 group were highest; the 25-and-under-30 next highest. Men 50 years and over were lowest in all years. Having, then, every reason to conclude that

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TABLE 54.—PROPORTION OF ANNUAL SEPARATIONS BY AGE, 1922-1924

AGE	1922 *				1923				1924			
	Total	Resig- nations	Dis- charges	Lay Offs	Total	Resig- nations	Dis- charges	Lay Offs	Total	Resig- nations	Dis- charges	Lay Offs
<i>Firm 2</i>												
Under 20 yrs.	23.5	14.7	5.1	3.7	24.0	15.7	3.8	4.5	19.4	11.9	5.1	2.4
20 yrs. and under 25 yrs.	27.5	18.2	3.7	5.6	28.7	21.2	4.4	3.1	30.0	20.3	6.6	3.1
25 yrs. " " 30 yrs.	17.6	12.4	1.4	3.8	16.2	11.6	2.1	2.5	17.9	13.5	3.6	0.8
30 yrs. " " 35 yrs.	9.3	6.6	1.3	1.4	10.4	7.9	1.2	1.3	9.9	6.1	2.9	0.9
35 yrs. " " 40 yrs.	7.8	4.8	1.6	1.4	6.6	5.0	1.2	0.4	6.5	3.9	1.5	1.1
40 yrs. " " 45 yrs.	5.7	4.1	0.4	1.2	4.8	3.9	0.6	0.3	3.3	2.6	0.6	0.1
45 yrs. " " 50 yrs.	3.8	2.6	0.4	0.8	2.4	1.9	0.3	0.2	2.8	1.3	0.6	0.9
50 yrs. and over	4.4	2.2	0.8	1.4	3.1	2.4	0.3	0.4	4.5	2.6	1.2	0.7
Unknown	0.4	0.4	....	....	3.8	2.1	0.3	1.4	5.7	3.3	1.0	1.4
Total	100.0	66.0	14.7	19.3	100.0	71.7	14.2	14.1	100.0	65.5	23.1	11.4
<i>Firm 14</i>												
Under 20 yrs.	37.8	32.7	3.9	1.2	43.2	38.3	4.0	0.9	24.2	8.4	1.6	14.2
20 yrs. and under 25 yrs.	15.9	13.2	1.9	0.8	16.2	14.4	1.2	0.6	16.9	9.5	....	7.4
25 yrs. " " 30 yrs.	11.4	8.6	2.0	0.8	11.8	10.5	0.4	0.9	16.8	10.0	1.6	5.2
30 yrs. " " 35 yrs.	12.4	9.8	1.8	0.8	9.5	8.9	0.3	0.3	12.6	4.7	1.1	6.8
35 yrs. " " 40 yrs.	9.1	8.1	0.6	0.4	8.3	6.4	0.9	1.0	10.0	2.6	....	7.4
40 yrs. " " 45 yrs.	7.1	6.1	0.6	0.4	5.6	4.8	0.3	0.5	6.3	3.2	1.5	1.6
45 yrs. " " 50 yrs.	2.4	1.8	0.6	....	3.5	2.9	0.5	0.1	5.8	4.2	....	1.6
50 yrs. and over	2.9	2.4	....	0.5	1.7	0.9	0.1	0.7	7.4	2.7	....	4.7
Unknown	1.0	0.8	0.2	....	0.2	0.2	....	....	....	....	....	....
Total	100.0	83.5	11.6	4.9	100.0	87.3	7.7	5.0	100.0	45.3	5.8	49.9

* Only 9 months for Firm 2. Only 11 months for Firm 14.

employees 20 and under 25 years cause a disproportionate amount of the turnover in each of three years, can the instability be explained by occupation or length of service?

The proportion of turnover found in each of the age groups is shown for three years in two other firms. These plants have little difference from year to year in the amounts due to varying ages. They are unlike the firm first considered in employing many under 20 and a high proportion under 18.

In these plants the proportion of separations varies inversely with age except in the under-20 interval in Firm 2. Discharges are relatively high for the group under 20. In the record on the table the constancy in the proportion for each age group in the three years is very striking, but without analyses of the distribution in the working force no definite opinion of the stability of age groups is warranted.

Though data are compiled for age groups by length of service, it is difficult to find a summary way to present such conclusions as the material warrants. The practice of averaging the length of service of different age groups

cannot be followed. The average for younger groups will be lower than for those 30 years and over, owing to the weighting of long service in the separations of older employees. At the same time, younger employees may not have the highest averages if shorter intervals of employment alone are considered. For instance, at Firm 2, in 1923 no group between 20 and 35 years had a loss in the first three months proportionate to the groups between 35 and 50 years. When a period of a year or more is considered, the proportion of older employees leaving lessens markedly without a corresponding decrease in the loss of younger employees. Apprenticeship and other training courses affect, of course, the amount of change of employees under 20. Again, women employees, though causing a high turnover in the course of a year or more, show low proportionate losses in the first months of employment.

There is doubtless some dependence of length of service upon age if considered by occupational groups. For this comparison no comprehensive data are available over a considerable period.

CHAPTER XI

METHOD OF COMPILATION

This report deals with turnover in a small number of plants in one area. The local character of the study is not accidental. It is part of the plan of research of the Department to confine its major studies to the area of the Philadelphia labor market, using the term "market," however, in a wide enough sense to include nearby suburbs and important manufacturing centers of eastern Pennsylvania. In fact, Wilmington, in Delaware and Camden, in New Jersey, often compete equally with Philadelphia in their demand for skilled labor. The area, then, practically must include the territory commonly considered under the Third Federal Reserve Banking District. This limitation of area makes possible a continuous contact with members as well as background of knowledge concerning community factors which are common to all concerns in influencing workers. It is this knowledge of the background of local factors that should in time make the work of the Department of greatest value. Nowhere before has there been an attempt, over a long period, to study seriously the problems of a single local market.

NEED FOR INDUSTRIAL RESEARCH

The Industrial Research Department grew out of the need for careful study of some of the problems of personnel—a need felt both by industrial concerns and educational institutions. For a decade before the war, many individual firms in widely scattered industrial centers, in the United States and Europe, had experimented with the centralization of certain functions relating to the selection, training and follow-up of their employees. These activities tended to run

to peaks according to the needs of the organization or the individual manager's conception of his obligation to his employees. The war activity and the shortage of labor hastened the starting of new departments, which in the main tended to copy organization and methods as worked out by early experimenters. During the war immediate matters of production were so pressing that no time was available for detailed study, however valuable the conclusions might be in the long run. The very pressure of the war production situation had, however, stimulated discussion and furthered the pooling of information. Employment managers' associations were organized in local areas where executives interested in labor problems met regularly to exchange experiences. Much of value and inspiration was brought out in these discussions. As time went on, however, there was needed some sifting of the worth of experiences, some analysis of the comparability of the conditions and methods and some conclusions as to what things had been established by the cumulative experiences of everyone.

The records of the Department were started after the war experiences ended, even after the post-war activity was past. It was necessary to include only firms with organized personnel activities, moderately well equipped with adequate record systems. Within limits, the plants could have, and may have, made regularly an analysis of their own turnover records. Within limits certain analysis can be made in each plant. Yet no plant exists unto itself. Its labor supply is affected by community, climatic and seasonal factors. The data of a plant be-

come valuable in so far as the concern can avail itself of the knowledge of the effect of these factors in other plants.

Difficulty arises, however, whenever plants begin to compare with each other. For purposes of comparison, data at each plant must be collected and compiled in the same way; records must be continued consecutively over a fairly long time; and occupational titles must be defined and used with a common connotation. To make occupational comparisons valuable, titles should be defined carefully and should be used in all plants in accordance with the descriptions agreed upon. For any such program, there is needed a common clearing house. With any start of common definition for one study, it is quite possible to widen the studies for which such standardization can be used effectively. With the necessity for comparable data in mind, a group of plants willing to experiment with standard practice and forms were selected. Any reliability that may now be claimed for conclusions is dependent upon uniformity in methods of reporting.

METHODS OF CLASSIFYING SEPARATIONS

These methods are essential to an understanding of the analyses of this study and the bulletin on methods is reprinted for the convenience of readers in Appendix A, though it is already available in print. Consultation of this section may be necessary for an explanation of the terminology used in analysis.

In the first period of collection of data, emphasis was placed upon the major causes for separation as given by employees leaving jobs. These were classified according to occupation, department, age, sex and length of service. The departmental classifica-

tion has been continued owing to its value to individual plants in locating parts of the organization where loss of employees is excessively concentrated. This figure has an immediate value to a concern. For general interpretation it yields no long run conclusions owing to the inclusion of skilled and unskilled occupations in the operating unit.

BASIS USED IN TURNOVER COMPILATION

Largely in accordance with the most frequent practice in plants, the denominator in the turnover ratio was based upon the average number on the roll. This necessitated similar methods of clearing rolls and the calculation of an average monthly figure from the weekly payrolls. The necessity of standardization is not due, primarily, to the need of uniform methods in clearing rolls, though this is important. In some cases, the office payroll has a way of getting included in the number considered "on the roll," though there may be no inclusion of office separations. Again, employees hired for temporary jobs may fail to be reported as separations when the job terminates, though their names appear on the payroll and their group helps to swell the average for a month in terms of numbers employed. One firm may be keeping a turnover record of hourly paid employees only, while another includes all employees, whatever their salary status in both separations and number enrolled. These problems confront one in making inter-firm comparisons whether the base be the average on the roll or the average in attendance. The varying methods result from differences in the scope of the personnel department. If the responsibility for placing office employees centers in the personnel office, these groups are likely to be covered by the turnover records. When the groups

are large, the weighting may considerably reduce the apparent turnover rate of the concern. Throughout the preceding analysis the average number on the roll was used to give a general picture of the turnover situation as a whole. It was supplemented by more detailed figures to show the nature as well as the amount of turnover based upon separations.

PRESENT EMPHASIS IN COLLECTING DATA

The preliminary study dealt mainly with reasons for plant terminations. At most, such a study, based on separations, granting the adequacy of assigned causes for leaving, gives only the reasons why men leave plants. It stresses one-third of the stability problem. Quite as important as the length of service of *separated* employes is the length of service of those who remain at work. Mistaken impressions may result from the continuous emphasis upon separations. Nor would the impression be improved by including a study of entrances, though this is a valuable figure. Even the consideration of entrances and separations would still stress fluctuations without adequate attention to percentage of permanent groups in the organization. After four years of study our present tendency is to shift the emphasis from a turnover figure to a comparison of the proportion of employes on the active roll by contrast with the proportions that these groups contribute to separations. To this end, experiments have been made in the standardization of records for keeping up to date monthly an audit of the rolls of active forces. Wherever figures on this basis were available, they have been used in chapters of this study as supplementary to the separations figures. This centers attention upon groups in the organization where the proportion of

changes in personnel exceeds the proportions that the group constitutes of the total payroll. It gives a simple and easily understandable calculation. To be sure, the method does not meet the objections of those who discard the number on the roll as an adequate basis for turnover calculation.

CLASSIFICATION OF OCCUPATIONS BY GRADE OF SKILL

In addition to the use of percentages of the active force, much time has been given to a classification of occupations according to grades of skill. Again, a long period of experimentation must elapse before much validity can be attached to conclusions. However, one of the newest phases of this report will be found in the chapter dealing with the results of this classification of occupation. Preceding chapters present correlation of the relation of skill to education and nationality in a limited number of plants.

The main part of the study deals with the monthly rate of separations and the nature of these separations as revealed in the major reasons assigned for leaving. When collection of data for this study was first undertaken, the dominance of market factors was not appreciated. The type of analysis given in the chapters on occupations, age, education and nationality was undertaken to explain the variation in turnover from plant to plant. It is now evident that study of these factors yields conflicting conclusions unless analysis is first made of market factors. Adjustments within an occupational group may be more largely due to the supply of workers than to the grade of skill. There is much need for intensive analyses after this market dominance is isolated. Only then may one attempt to say what part of turnover is within the *immediate* control of individual plants.

APPENDIX A—BULLETIN ON METHODS

I—REASON FOR THE SELECTION OF THE LABOR TURNOVER STUDY

A NUMBER of factors influenced the Department in selecting Labor Turnover as its initial point of attack. In the first place it must be borne in mind that the Department was started in the deep trough of the depression period. At a time when firms are scanning costs carefully the expense of the mobility of employees is not the most important item. In fact the quitting of an employee usually relieves someone in the organization from the unpleasant task of laying him or his fellow off. Capital and new orders are for the time being the important considerations. Inevitably emphasis must be turned to the scarcest factor in the business situation. Since this is not labor, there will be a tendency to cut down the keeping of labor-department records, and the analysis of such data will seem of little interest. This management point of view is well expressed in the following quotation from the letter of an executive in a very co-operative firm sent to the Department during the depression of 1921:

We have not been hiring anyone for almost two years and the folks leaving our employ do not leave because of any dissatisfaction either on their part or ours. The few that do leave our employ are fortunate enough to secure some other work that for the time being pays them better. This is not a true condition of affairs. In fact, I feel that all efforts of comparison at the present time are a waste of time and effort.

When business has improved sufficiently so that industrial plants are building up and have cause to hold their present corps of workers, it is then that comparisons become valuable. If you could conserve your fund until it would mean something to industrial plants, I believe you would have a great many interested whom you could not interest today.

Among the firms, then, there are wide gaps likely to occur in the recording of data during a depression and still wider omissions in the analysis of records. For two reasons this is unfortunate. First, from the broader point of view of the control of business depressions, information will be lacking upon which to base a control policy. Second, and more important, from the point of view of the plant itself there will be no careful watching of the shift in stability as the industries begin to return to activity.

For instance, the improved employment situation in April of 1922 was reflected at once in every plant reporting in the group by a marked increase in turnover among laborers. This occupational group alone accounted for the moving upward of the total turnover at a time when lay offs had become less of a factor.

Conditions, then, inherent in the business situation, would have pointed to labor turnover as a subject likely to yield some information otherwise certain to be permanently lost. Besides it was important that a subject be chosen which was of interest to all plants. Even when plants have not been able to provide the careful interviewing and extra recording which is necessary to co-operate directly in the turnover study, there has been much interest in the comparisons of other firms. It was then not only a subject known to every one, but one in which group comparisons were undoubtedly of great value.

From the point of view of research the interest of the firms in the subject made possible regular and continuous monthly reporting. In any work where standardization is necessary for comparisons, records must be continued for some time in order to make the adjustments necessary to secure uniform data. For this reason the early months and in fact the first year of work was really preliminary despite the fact that much had been done in this field by previous investigators.

Perhaps the most cogent reason for the selection of this particular study was the fact that it was one in which firms are concerned both with its immediate computation and with its long-run trends and tendencies in interpreting their own experience and in utilizing the experience of others. Whenever attention is directed to long-run tendencies, the discussion of a study inevitably points to conclusions which cannot be drawn owing to paucity of data or inability to cover the field. Turnover in itself is in many cases a symptom, not a cause. For this reason the future of the Department will lead it to plough deeper into many of the problems now growing out of the turnover approach.

II—COLLECTION OF DATA

The first step in a community study of labor turnover involved the issue of a bulletin of standard practice in classifying reasons for leaving. The Department does not claim credit for original methods in this grouping. Work already done by individual plants, as well as by industrial students, had been co-ordinated by The Scott Company. To this, much was added by their group of technically trained men and the results arranged in workable form in their Day Book Code. In adapting this material to its needs the Department had the assistance of Mr. Donald Paterson, now of the University of Minnesota. The heartiness with which the bulletin has been accepted in Philadelphia and other areas, is due to Mr. Paterson's experience in avoiding overemphasis upon reasons of immediate importance at the expense of those likely to appear with industrial recovery.

Even now, no finality is claimed for the bulletin as here printed. Slight modifications have been made in it during the four

years of use. Doubtless other students will modify parts of it still more. It has served to classify the records of twenty-five firms, representing widely different industries. The advantage of the bulletin has been that reports from plants were received in detail with an effort to retain as much as possible of the atmosphere of the shop. A grouping is made into general classes, at the same time that the shop detail is recorded in the computation, which goes to each firm. The more general classes are useful for comparisons with other plants. When groupings are made in one plant on the basis of its own experience, consideration is likely to be given to some factor important at the moment; no provision is usually made for new reasons. When this reason occurs it must either be classed under "miscellaneous" or occasion a wholly new grouping.

A sample is here shown of the way in which raw material is reported to the Department:

CAUSES OF LEAVING

NAME OR NUMBER	RACE AND SEX	DEPARTMENT	POSITION HELD	DATE ENTERED	DATE LEFT	REASON FOR LEAVING
W. Thompson..	C M F	Janitor Service	Cleaner	5-17-21	5-30-22	R D L M Accident—home burned
J. Doe.....	C M F	N. V.	Grinder	5-14-22	5-17-22	R D Did not feel grinding L M was his vocation
M. Smith.....	C M F	Engine	Operator	5- 1-22	5-20-22	R D L M Inattentive to her work
L. Allen.....	C M F	"	"	4-13-22	5-20-22	R D Mechanics could not L M get machine fixed
B. Donnelly...	C M F	"	Inspector	3-30-22	5-25-22	R D L M Better paying job
	C M F					R D L M

These detailed reasons are grouped by the Department according to instruction printed in the following chapter.

III—SUGGESTIONS FOR GREATER UNIFORMITY IN THE STUDY OF LABOR TURNOVER

ANALYSIS OF REASONS FOR LEAVING

1. *Main Classifications*

There is no common understanding of the meaning of the terms "Resignation," "Discharge," "Laid Off," in the various reports studied so far. For example the following classifications were found in a single report from one company:

Inefficient—Discharge
Not Efficient—Laid Off
Not Steady—Discharge
Unsteady—Laid Off

It is proposed that all exits be classified into one of the following three groups: "Resignation," "Discharge," and "Laid Off." The classification of an exit into one of these three groups should be based on the following definitions:

A *resignation* occurs whenever an employe terminates his service with a company.

A *discharge* occurs whenever a company terminates the services of an employe because of some real or imagined fault of the employe.

A *lay off* occurs whenever a company terminates the services of an employe because of a lack of work.

(*Note:* A fourth group of "Miscellaneous Reasons" covering death, injury, old age, etc., occur rarely. Such reasons are of little practical importance and can be classified under Resignations.)

2. *Minor Classifications*

There is no standard list of the reasons for leaving now in general use. Some companies use a very short list and soon discover that many exceptional reasons occur that fall outside the list. Other companies go to the extreme of using an unlimited number of reasons and experience great difficulty in attempting to compare the nature of the turnover in one period with that of another period. Such an unlimited list of reasons leads to unwieldy turnover reports. The following list of reasons is proposed as a suitable compromise. This list yields definiteness in that

practically all possible reasons can be readily classified. At the same time its major subdivisions are few enough to make comparisons easy and to keep periodic turnover reports reasonably short.

REASONS FOR LEAVING

R. RESIGNATIONS	Code No.
1. <i>Dissatisfaction with Wages</i>	10
<i>Specific Reasons</i>	
Rate.....	11
Earnings.....	12
Uncertainty of amount.....	13
Method of computing.....	14
Method of pay.....	15
2. <i>Dissatisfaction with Nature of Job or Working Conditions</i>	20
<i>Specific Reasons</i>	
Work too hard or too heavy.....	21
" " dirty.....	22
" " dusty.....	23
" " wet.....	24
" " smoky.....	25
" " cold.....	26
" " hot.....	27
" " noisy.....	28
" " oily.....	29
" " dangerous.....	30
" " monotonous.....	31
Work causes too much nerve strain.....	32
Work causes too much eye strain.....	33
Poor lighting.....	34
Unpleasant smells.....	35
Unsatisfactory toilet facilities.....	36
Unsanitary conditions.....	37
Work unhealthful.....	38
Machines too high.....	39
3. <i>Dissatisfaction with Hours or Time of Work</i>	40
<i>Specific Reasons</i>	
Hours too long.....	41
Hours too unhandy.....	42
Night work.....	43
Sunday work.....	44
Seven days' work.....	45
Lost time.....	46
Overtime.....	47
4. <i>Dissatisfaction with Labor Policies</i>	50
<i>Specific Reasons</i>	
Dislike of management.....	51
" " foreman.....	52

Unadjusted grievance.....	53	Quit without notice.....	108
Request for transfer refused	54	Hired but failed to report....	104
No chance to advance.....	55		
Labor trouble threatened....	56	D. DISCHARGES	
Strike.....	57	1. Discharged for Incompetency.....	110
Desire for vacation or change of work.....	58	<i>Specific Reasons</i>	
		Worker is slow.....	111
5. More Attractive Opportunities		Physically unadapted.....	112
Elsewhere.....	60	Incompetent.....	113
<i>Specific Reasons</i>		Spoiling work.....	114
To take job with better pay.	61		
To take job with better hours	62	2. Discharged for Disciplinary Rea- sons.....	120
To take job with better future.....	63	<i>Specific Reasons</i>	
To go into business for self.	64	Careless.....	121
To retire.....	65	Lazy.....	122
To take former job.....	66	Caught loafing or sleeping ..	123
To work at trade.....	67	Habitually absent.....	124
To go to school.....	68	Unreliable.....	126
To join army or navy.....	69	Disagreeable.....	127
6. Community and Family Reasons.	70	Dissatisfied.....	128
<i>Specific Reasons</i>		Chronic kicker.....	129
Sickness in family.....	71	Disturber or trouble maker..	130
Needed at home.....	72	Refused transfer.....	131
Family moving.....	73	Violation of rules.....	132
Dislike of city.....	74	Insubordination.....	133
Dislike of climate.....	75	Dishonesty.....	134
Housing conditions.....	76	Intoxication.....	135
Poor schools.....	77	Immoral.....	136
Narrow acquaintances.....	78	Fighting.....	137
Factory too far from home..	79		
7. Personal Reasons.....	80	L. LAY OFFS	
<i>Specific Reasons</i>		1. Business Conditions.....	140
Wanderlust.....	81	<i>Specific Reasons</i>	
To accompany a friend leav- ing.....	82	Industrial depression.....	141
Leaving city.....	83	Cancellation of orders.....	142
Leaving U. S.....	84	Seasonal fluctuation.....	143
Marriage.....	85	Completion of temporary work.....	144
Leave of absence.....	86		
8. Physical Reasons.....	90	2. Manufacturing Conditions	
<i>Specific Reasons</i>		<i>Specific Reasons</i>	
Superannuated or pensioned	91	Change in industrial proc- esses.....	151
Death, occupational causes	92	Discontinuance of depart- ment.....	152
“ exterior “.....	93	Shortage of material.....	153
Ill-health due to factory work.....	94	Breakdown.....	154
Ill-health due to exterior factors.....	95	Strike or lockout.....	155
Injury from work.....	96		
Injury from outside causes..	97	In using the above list of reasons for leaving it is recommended that a record of the specific reason for the departure of each employee be kept. The tabulated turnover reports should then use the major headings as a matter of routine. In this way de- tailed data are always available for more minute analysis if desirable. For example, should a company's report show an unusu-	
Pregnancy.....	98		
9. Reasons Unknown.....	100		
<i>Specific Reasons</i>			
No reason given.....	101		
Left without final interview	102		

In using the above list of reasons for leaving it is recommended that a record of the specific reason for the departure of each employee be kept. The tabulated turnover reports should then use the major headings as a matter of routine. In this way detailed data are always available for more minute analysis if desirable. For example, should a company's report show an unusu-

ally large number of resignations because of reason 20 (dissatisfaction with nature of job and working conditions), it would be a simple matter to prepare an additional report that would show exactly what specific working conditions were responsible for the situation.

This recommendation is based on the principle that labor turnover studies should primarily reveal general tendencies with emphasis on details only when the details seem to be important.

No attempt has been made to classify reasons for leaving as "avoidable" or "unavoidable." Experience has shown such classifications to be unsatisfactory and in some cases misleading. It is difficult to classify any particular case of turnover as avoidable or unavoidable. A particular discharge may be unavoidable at the moment, yet discharges are clearly avoidable in the majority of cases, for they represent an error in selection and placement by the employment department, inadequate training or upgrading of the employe in his job or the lack of effective leadership in managing him. Yet some companies classify discharges as unavoidable while other companies classify discharges as avoidable. Such lack of uniformity makes it difficult to interpret the turnover reports issued by different plants.

Again, a ten per cent lay off because of seasonal fluctuation of the business may for the moment be unavoidable. Had a different sales policy been in effect or perhaps had a manufacturing-to-stock policy or a manufacturing of a side-line product policy been in effect, it is possible that no such lay offs would have been necessary.

Ill-health and sickness are classified by some firms as unavoidable. Experience has shown that it is possible to cut down a certain amount of turnover for such reasons through medical examination, medical advice, first aid, nursing service and campaigns of education in hygiene and right living.

Even such a limited consideration of "avoidable" and "unavoidable" reasons indicates the impossibility of making such classification with even a fair amount of accuracy. For this reason an effort is here abandoned and a procedure is recommended that will give uniform results from

one company to another if the simple definitions of "resignation," "discharge" and "laid off" are adhered to.

The purpose of the classification here proposed is to bring about greater uniformity in labor turnover studies in order that one company may know how its turnover problem at one period compares with that of another period.

COMPUTATION OF LABOR TURNOVER

The lack of uniformity in classifying reasons is paralleled by a similar lack of uniformity in methods of computing labor turnover. Without discussing the merits of the various methods it is proposed that the following method of computation be adopted. State labor turnover in the form of the percentage of the number of terminations of employment to the average force on the payroll during the year. For example, if the average force on the payroll during a year is 50 and the number of terminations during the year is 50, the turnover for the year is 100 per cent. That is, the number of terminations (50) is divided by the average force (50). The result is a percentage figure of 100.

This method recognizes the necessity for expressing labor turnover by a figure that reflects not only the significance of changes from the point of view of cost to the employer but also from the point of view of cost to the public and the employe. This method gives a general picture of the turnover situation as a whole.

It must be recognized that a labor turnover percentage in itself gives only a vague idea of labor fluctuation. It needs to be broken down so as to show the "Resignation Turnover Per Cent," the "Discharge Turnover Per Cent" and the "Lay Off Turnover Per Cent." Indeed it may even be desirable to show turnover percentages for various specific groups of reasons. By such a procedure the nature of the turnover as well as the amount of turnover is revealed.

REDUCING ALL TURNOVER PERCENTAGES TO A COMMON BASIS

Labor turnover reports may be issued weekly, monthly, quarterly, semi-annually. Within a given company all of these reports

might be issued as a matter of routine. If all such reports reduce the turnover percentage to a yearly basis it is evident that the amount of turnover for a week, a month or a quarter, may then be directly compared.

The procedure for reducing the turnover for a given period to an annual basis is as follows:

1. *Weekly figures.* The number of terminations occurring during the week is multiplied by 52 to show how many terminations would occur during a year if the number of terminations were to continue at the same rate. Dividing this number by the average payroll for the week gives the desired turnover percentages on an annual basis.

2. *Monthly figures.* If the figures cover terminations for a four-week period then you multiply the number of terminations by 13 to get the number that would occur during a year at the same rate. If the figures cover a five-week period then multiply by 10.4, because five weeks go into the 52 weeks in a year ten and four-tenths times. If a calendar month is used multiply by twelve. Dividing this number by the average payroll for the month gives the turnover on a yearly basis. The average payroll for the month is found by adding the number on the payroll at the beginning of the month and at the end of the month and then dividing by 2.

3. *Quarterly figures.* The figures should cover a 13-week period (made up of two four-week and one five-week periods). The number of terminations during the 13-week period is multiplied by four to get the number that would occur in a year's time. This is then divided by the average payroll for the quarter (i.e. the average of the three average monthly payrolls).

ANALYSIS OF TURNOVER BY DEPARTMENTS

Ordinarily, turnover by departments should be analyzed to the extent of showing the amount of turnover for each department and the reasons for leaving each department. In this way the departments in which the turnover is most heavily concentrated are automatically pointed out. The tabulation of the reasons for leaving each department shows immediately what

caused the excessive turnover in those departments.

To carry forward this analysis as a routine matter implies the existence of figures showing the number of employees on the payroll by departments as well as a record showing the department in which each exit was employed and the reason for the departure of each exit.

ANALYSIS OF TURNOVER BY OCCUPATIONS OR CRAFTS

If the occupations in the company have been carefully classified and arranged in a workable Occupational Index, it is then possible to carry forward an analysis of turnover by occupations. Here again the purpose is to identify those occupations in which labor turnover is excessive. The reasons for leaving each occupational group should also be tabulated so that the cause of excessive turnover in any occupational group may readily be determined.

Such occupational analyses become unwieldy unless all similar occupations have been grouped together in an index. With an index listing twenty or thirty major occupational groups it is a simple matter to carry forward the number of employees in each of these groups to tabulate the number of exits from each group and to record the reason for leaving. Occupational analyses of this sort are of unusual value because of the relation of wages to occupations and because competition for labor on the part of other firms is usually a competition by crafts.

It is unfortunate for purposes of the co-operative study of turnover in a given industry or in a given community that there is no standard occupational index in existence. The nearest approach is the "Trade Specifications and Index of Professions and Trades in the Army" issued by the War Department on March 21, 1918. It is doubtful whether the companies co-operating in these labor turnover studies would gain much by the use of the Army Index. The co-operating companies represent many different industries so that relatively few occupations are common to them all or even to a small number. For this reason the occupational index would be a very lengthy and bulky affair, only a

small part of the index being applicable to any particular company.

The situation seems to demand a separate occupational index for each company. Since many companies do not have a systematized classification of their jobs at present it is recommended that each company should prepare an index for itself. This index with the turnover record should be submitted to the Industrial Research Department to facilitate occupational turnover analyses for each company.

ANALYSIS OF TURNOVER BY LENGTH OF SERVICE

It is important to study turnover in relation to length of service to determine whether turnover is excessive among new employed or whether it is excessive among any other length of service group. Turnover for a company as a whole may be relatively small and yet an excessive turnover may exist among some particular length of service group. To definitely measure turnover in relation to length of service is ordinarily difficult, for it involves a periodic inventory of the length of service of employes on the job. This type of analysis has rarely been made.

The usual procedure and the procedure here recommended for routine turnover reports consists in recording the length of service of each exit, tabulating the distribution of the length of service of exit in such a way as to compare the length of service of those exits who resign, are discharged or laid off.

ANALYSIS OF TURNOVER BY AGE

A record of the age of each exit will permit the Research Department to study important relationships between age and sex, and turnover in certain occupations. For example, a very definite and important relationship has been found by some companies between age and stability of common laborers. It will take considerable research work to discover how universal such relationships are—each company can make a real contribution to these studies by furnishing the necessary age and occupational data about each exit.

TURNOVER BY EDUCATION, NATIONALITY, DEPENDENTS AND MARITAL STATUS

No question of turnover is of greater importance than the relation of education to occupational satisfaction. A few experimental studies give much promise. Unless the education record is carefully procured, conclusions will be misleading. It is necessary to know the age at which the exit left school as well as the grade attained. The accumulation of data concerning the education, nationality, dependents, etc., of each exit from the various co-operating companies will in time permit the Research Department to make studies of the relationship between turnover and these various factors. At the present time there is much speculation and numerous opinions concerning the effect of these factors on turnover, but little actual knowledge is available. Results from the reporting of such detailed data could be secured only after a considerable time. It is believed, however, that study of these factors will yield results that will, in the long run, more than repay the co-operating concerns for the expense involved in submitting to the Department such data concerning each exit.

SUMMARY OF DATA TO BE SUBMITTED BY CO-OPERATING CONCERNS

The following data should be submitted *monthly* to the Department by each of the companies co-operating in the study of labor turnover:

1. *Departmental Labor Inventory.* This is a list of the departments showing the number of employes on each departmental payroll on the first day of the month.
2. *Occupational Labor Inventory.* This is a list of the major occupations showing the number of employes in each major occupation on the first day of the month.
3. *Data Concerning Exits.* This is a list of all exits during the preceding month, showing for each exit the department, occupation, specific reason for leaving, length of service, age and sex.

The Department will issue record sheets that will facilitate the recording of data.

To save space on the record sheet and to reduce the clerical work involved in entering the data it is necessary to print on the record sheet itself certain items that only need to be circled in making an entry. The items are as follows:

Age:—Blank space for entry of date of birth.

Race and Sex:—Letters M and F printed on record sheet. Circle M in case of male and F in case of female exit. Colored will be indicated by circling C as well as male and female.

Length of Service:—Two spaces provided for the date of entrance and date of leaving, showing the total length of service of the employee.

Reason for Leaving:—Letters R, D, L, M, printed on record. Circle R for resignations, D for discharges, L for laid off, M for miscellaneous. Space for entering the specific reason for leaving. See "Reasons for Leaving" list. Circling the letter for items is insufficient. A detailed reason should also be given.

Department:—Space for entering the name of the department being left by the exit.

Occupation:—Space for entering the name of the occupation the person is leaving. These names to be furnished by each company for its own list of occupations.

REPORTS TO CO-OPERATING COMPANIES BY THE DEPARTMENT

The chief value of an elaborate turnover report lies in the discovery of trends and tendencies that need correction. Monthly

reports are apt to reflect momentary conditions that are absent in subsequent months. The short weekly and monthly reports usually compiled within a company reveal these momentary conditions to a sufficient extent for all immediate purposes.

Detailed turnover reports that will disclose important trends and tendencies need to cover a number of months. It is probable that quarterly reports will best serve this purpose.

Such quarterly reports will include an analysis of changes in the amount, nature and causes of turnover from month to month. In this way those conditions that exist in only one or two months will be concentrated with the more important trends that show up for a number of months.

The Department will tabulate the turnover figures from each company at the end of each month and at the end of each three months' period will prepare a special report. The special quarterly report for any company will concern itself, of course, with the turnover figures for that company alone.

In this way each company will receive a direct service from the Department relative to its own turnover figures. At the same time the Department will be able to render a more general service by supplying all the companies those general facts and relationships that are discovered from time to time and such comparisons as are at all useful and comparable.

IV—DISCUSSION OF GROUPING OF MAJOR CLASSIFICATIONS

SIGNIFICANCE OF MAIN DIVISIONS AND MAJOR REASONS OF TURNOVER

Nine major reasons will be found under Resignations:

- (1) Dissatisfaction with wages.
- (2) Dissatisfaction with nature of job or working conditions.
- (3) Dissatisfaction with hours or time of work.
- (4) Dissatisfaction with labor policies.
- (5) More attractive opportunities elsewhere.

- (6) Community and family reasons.
- (7) Personal reasons.
- (8) Physical reasons.
- (9) Reason unknown.

The first four groups show roughly the relation of the employee to his own plant, the fifth deals with the employee in his relation to other plants, the sixth and seventh attempt to distinguish between social and personal reasons. This latter classification is significant mainly in the industries employing women, since a large item in the

"personal" group is due to resignations of women "to be married." The "unknown" does not in most cases represent poor statistical reporting, but comprises rather the cases of employes who quit, giving such an indefinite reason that no one can distinguish between the primary cause and general dissatisfaction due to many circumstances.

Frequently questions arise concerning the reliability of reasons given to the interviewer of an employer. It is true that a worker rarely resigns for any one reason; his decision to leave is often influenced by a series of previous occurrences. Even at the time he leaves, secondary reasons are often given. The interviewer is forced to judge the circumstances that seem to be of most influence, by his knowledge of the character of the foreman, by his previous contact with the worker, or by difficulties in connection

with production or earnings at the time. In a large number of exits the secondary reason for one employe will appear as primary for another. Over a long period the reasons causing most difficulty should appear. The reasons given throughout this report are those secured by the interviewer at the plant reporting. It would be desirable to check certain reasons by personal interviewing after the employe has left the plant. For instance, when such interviewing is possible the "work elsewhere" group changes somewhat. But little work has been done in checking, nor would it be easy to do such work later. Besides many of the reasons would still be far from exact. There are rough checks in the figures themselves. Again, many reasons are too subtle to appear directly. For instance, relations between education

WORKING CONDITIONS AND LABOR POLICY

REASONS FOR LEAVING	TOTAL	REASONS FOR LEAVING	TOTAL
Disliked work	122	Work too hard on hands	1
Dissatisfied	30	Wanted home work	2
Work too hard	21	Changed to different work	5
<i>Machines</i>		Wanted only the best work	1
Wanted different machine	1	Wanted time work	1
Poor machine	4	Could not get used to points	1
Machine trouble	1	Dissatisfied with wool work	1
Dissatisfied with machine	13	Too much lint	1
<i>Routing of Work</i>		<i>Individual Preferences</i>	
Place had too much system	1	Disliked partner	1
Disliked system	2	Disliked surroundings	1
Had to wait too long for work	1	Disliked large work room	1
Work too different	1	Indoor work too confining	1
Objected to having work examined	1	Too many steps to climb	1
Changed machines too often	1	Did not know what she wanted	1
Wanted two machines	2	Never satisfied—fourth trial	1
Disliked running three machines	1	<i>Difficulty with Foreman or Rules</i>	
Wanted steady work on uniform product	1	Dissatisfied with demotion	2
<i>Type of Work</i>		Dissatisfied with foreman or forewoman	7
Wanted small work	1	Reprimanded for being lazy and left	1
Wanted different work	9	Too big for job	1
Wanted coarse work	1	Dissatisfied with being docked when absent for no good reason	1
Work too fine	3	Disliked rules	1
Work too hard on eyes	4	Broke rules—did not report	1
		GRAND TOTAL	253

and occupational satisfaction, between age and stability, between promotion and skill, etc., must be arrived at indirectly. Such a reason as "lacks confidence" often should be checked with the education and past experience of the worker—these more subtle causes being unknown to either worker or recorder.

To show that it is possible to get complaints that pertain to the work and the management, an analysis is here given of the detailed reasons, grouped under "Working Conditions" and "Labor Policy" at a textile plant, during 1921. From the reasons one might infer that the firm was operating with poor building and equipment. It is, in fact, a well conducted, modern plant, one of the best in the trade. Despite good lay out there still remains the question of routing of work and the interrelation of production as work advances through the shop, all of which affect the satisfaction and stability of employees.

Could anyone read over the list of reasons without realizing how closely

related are matters of industrial organization to employes' stability, in spite of the fact that some of the specific names of operations have been eliminated to prevent identification? One wonders what were the occupations and length of service of the one hundred and twenty-two persons who "disliked the work." These queries can be answered from the figures; there still remains the unanswered question of just what occasioned the dislike. In this case the employment manager does especially well in interviewing. He is not satisfied to write down abstract reasons, but, instead, is keeping a record of value to the production manager and foremen in correcting difficulties. Unfortunately the records of many employment departments are useful merely in keeping a file clerk busy. As long as personnel executives are willing to write down "dissatisfied, resigned, left," etc., with no further comment, they are not getting far in co-ordinating their work with the employe nor are they securing information worth the expense of recording.

APPENDIX B
TABLE 1—ANNUAL TURNOVER RATES BY MONTHS
Lay Offs, 1921-1924

MONTH	FIRM NUMBER																			
	1	2	3	4	6	7	8	9	10	11	12	14	15	16	17	18	19	21	24	
1921	20.2	10.3	106.9	45.0	0.0	24.6	40.1	....	110.3	15.3	....	....	23.0	....	....	....	....	....	19.5
	0.7	10.0	0.0	27.0	0.0	16.2	3.3	....	42.5	40.2	....	....	0.0	....	....	....	....	....	18.4
	1.2	32.6	18.4	6.0	65.8	23.6	16.8	....	19.5	36.4	....	....	3.3	....	....	....	....	....	0.0
	3.3	12.7	0.0	2.0	119.1	71.5	241.4	....	835.6	9.7	....	....	58.3	....	....	....	....	....	0.0
April.....	19.4	18.6	2.7	10.7	0.0	38.7	117.6	....	31.1	31.1	....	....	0.0	....	....	....	....	....	5.4
May.....	4.2	13.0	16.6	17.6	182.6	35.4	22.5	....	49.0	48.9	....	....	28.7	....	....	....	....	....	0.0
June.....	0.0	2.1	5.7	3.9	0.0	189.7	1.6	....	36.1	67.9	....	....	40.0	....	....	....	....	....	1.6
July.....	0.9	4.7	2.8	18.0	177.0	408.3	12.3	....	10.1	163.1	....	....	0.0	....	....	....	....	....	7.4
August.....	3.7	17.8	0.0	45.8	0.0	101.0	10.2	....	4.9	84.8	....	....	0.0	....	....	....	....	....	5.4
September..	5.6	7.7	2.9	75.9	21.4	165.0	83.5	26.2	13.3	25.2	3.3	....	9.5	....	....	....	....	....	0.0
October.....	5.4	15.4	0.0	22.0	0.0	114.0	70.1	65.8	0.0	8.4	....	....	96.6	0.0	5.5	0.0	....	....	61.3
November....	5.3	3.8	17.6	15.7	0.0	79.0	34.5	0.0	0.0	9.0	....	....	18.5	0.0	25.4	....	....	3.2	93.7
December...																				
1922	6.1	5.5	51.1	13.3	0.0	43.9	11.0	4.4	21.3	26.6	13.2	0.0	0.0	0.0	2.9	0.0	1.6	33.6	35.1	
	6.9	14.4	9.3	0.6	0.0	187.0	5.5	8.8	25.8	63.7	17.5	0.0	46.4	0.0	52.2	7.4	60.0	0.0	9.4	
	5.0	7.9	3.1	0.0	6.6	51.5	12.2	0.0	21.4	11.6	19.6	27.4	0.0	0.0	0.0	23.4	31.7	9.8	22.7	
	1.2	50.3	9.5	2.1	0.0	36.1	1.1	2.6	12.4	2.7	13.1	0.0	0.0	0.0	6.4	6.6	0.0	3.3	32.0	
April.....	2.9	3.6	9.7	0.0	6.5	17.1	2.3	0.0	7.6	1.2	1.6	0.0	0.0	0.0	6.4	0.0	6.8	0.0	55.0	
May.....	0.0	5.9	3.3	1.0	0.0	9.0	8.1	0.0	15.1	0.0	4.1	0.0	22.8	0.0	3.3	0.0	0.0	0.0	25.2	
June.....	0.0	5.2	3.2	0.4	0.0	17.3	11.9	0.0	7.0	23.0	7.2	9.5	5.8	0.0	6.7	0.0	1.7	8.5	4.0	
July.....	1.4	5.2	0.0	0.0	0.0	5.4	2.7	33.0	22.0	28.9	20.9	12.6	0.0	0.0	0.0	4.6	1.7	0.0	0.0	
August.....	2.2	8.2	0.0	14.1	0.0	8.1	1.3	203.8	19.0	0.6	6.2	2.8	0.0	0.0	0.0	0.0	1.7	0.0	3.6	
September..																				

FOUR YEARS OF LABOR MOBILITY

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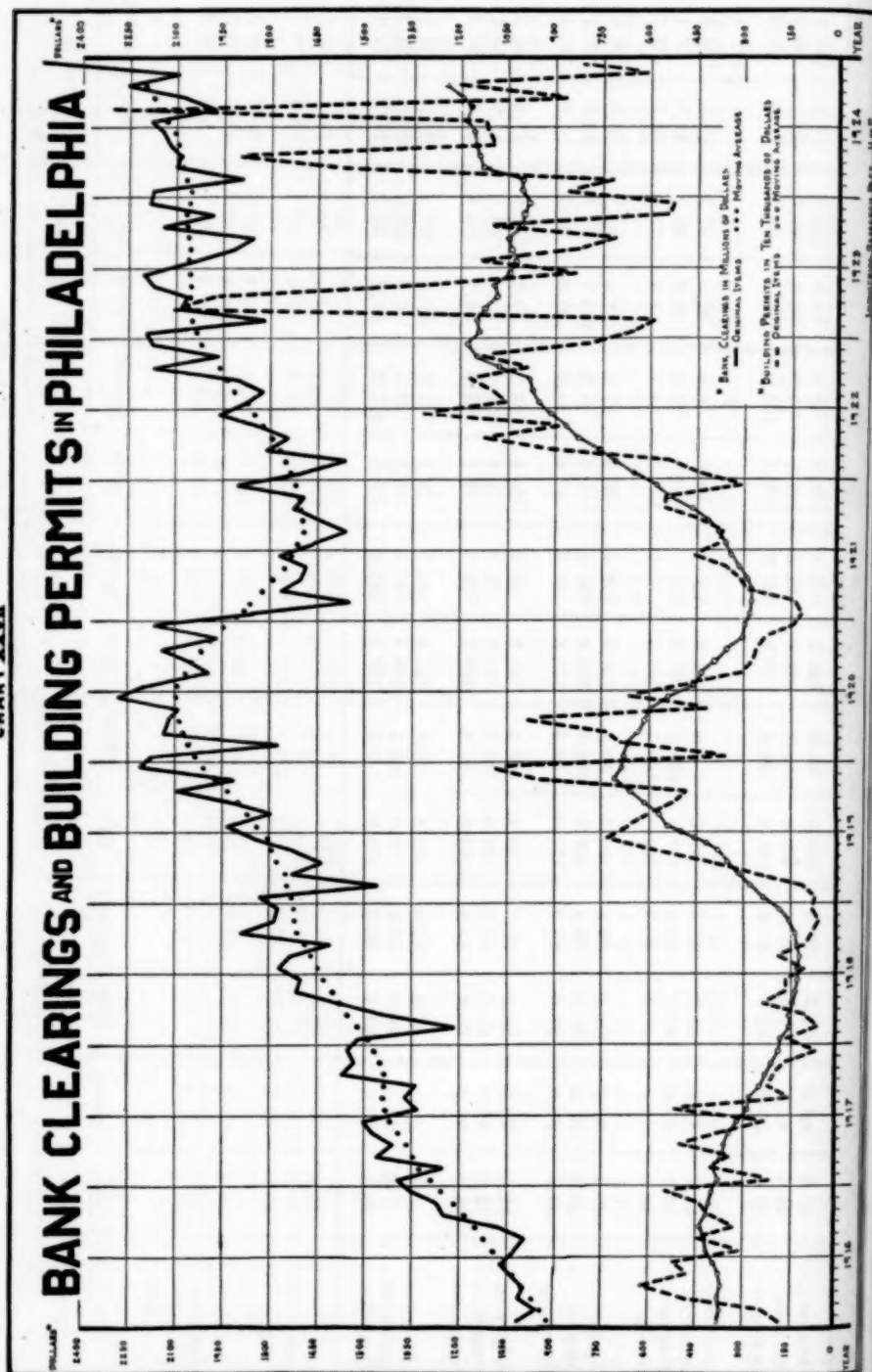
October.....	0.3	1.7	9.7	0.9	0.0	1.2	0.0	60.6	2.9	0.0	2.5	0.0	4.9	0.0	0.0	13.6	11.6	2.9	9.1
November....	0.3	6.4	6.2	0.0	0.0	0.8	0.0	4.5	0.0	0.0	4.7	18.3	0.0	0.0	0.0	0.0	1.7	5.7	11.4
December...	2.0	4.1	3.1	0.4	0.0	10.9	2.5	0.0	4.7	0.0	200.5	5.6	8.0	0.0	0.0	0.0	4.7	0.0	5.6
1923																			
January.....	0.0	1.2	6.2	0.0	0.0	84.5	2.4	9.5	9.1	1.1	9.7	12.0	2.7	0.0	2.7	0.0	12.5	0.0	7.5
February....	0.0	0.0	3.1	0.0	0.0	49.2	8.1	0.0	11.4	0.0	4.9	2.8	0.0	0.0	2.8	3.6	3.1	2.7	1.8
March.....	1.2	4.5	12.3	0.0	0.0	67.1	6.3	1.8	4.6	0.0	6.2	0.0	0.0	0.0	5.7	3.3	6.3	0.0	7.4
April.....	0.0	1.1	15.8	0.4	0.0	70.6	3.7	1.8	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	3.1	2.6	13.4
May.....	0.9	13.7	19.3	16.5	0.0	67.5	2.4	1.7	2.1	0.0	2.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	15.1
June.....	2.6	0.0	6.2	0.7	0.0	67.8	2.5	3.3	2.2	0.5	1.6	0.0	171.7	0.0	0.0	11.5	1.5	2.6	0.0
July.....	6.6	5.1	3.2	1.5	0.0	72.4	2.6	0.0	42.0	0.0	3.4	15.5	53.8	0.0	0.0	8.5	0.0	0.0	2.3
August.....	7.0	4.6	19.1	11.1	0.0	73.3	1.3	117.9	4.5	0.0	2.9	2.7	...	5.6	2.7	0.0	5.2	0.0	17.5
September...	8.7	3.4	31.6	10.0	0.0	66.4	1.2	112.1	30.6	0.0	2.0	39.6	...	0.0	0.0	0.0	1.8	0.0	...
October.....	9.7	54.5	3.6	3.3	0.0	62.5	5.7	34.3	72.2	0.0	4.2	6.0	...	0.0	0.0	13.8	0.0	107.0	...
November....	12.1	19.1	7.5	0.4	0.0	70.0	19.3	0.0	18.8	4.5	7.0	6.2	...	0.0	8.7	0.0	0.0	11.0	...
December...	8.8	7.5	15.7	1.7	0.0	70.2	23.2	2.4	2.4	8.6	174.2	29.1	...	2.9	2.9	0.0	1.7	5.4	...
1924																			
January.....	13.0	2.5	4.0	9.8	10.7	96.2	16.9	0.0	16.8	6.1	12.0	48.4	...	0.0	2.4	14.0	11.7	0.0	...
February....	7.6	1.3	12.4	46.6	0.0	96.9	2.5	6.5	7.3	13.1	5.7	19.3	...	0.0	2.9	0.0	5.0	0.0	...
March.....	2.5	1.2	0.0	4.5	0.0	42.3	9.1	2.1	0.0	8.6	10.2	9.5	...	0.0	2.8	14.7	16.7	23.3	...
April.....	1.7	24.2	4.2	51.4	17.1	74.8	7.6	2.0	75.0	3.4	7.1	38.8	...	13.7	0.0	361.9	0.0	65.8	...
May.....	9.4	1.8	17.0	82.4	5.8	58.7	4.5	2.5	86.7	0.0	5.9	101.2	...	0.0	0.0	24.8	5.2	35.7	...
June.....	32.9	0.0	0.0	155.2	0.0	33.7	12.6	154.4	56.4	0.0	2.8	52.5	...	0.0	0.0	20.9	8.7	53.5	...
July.....	3.3	1.8	0.0	10.0	70.2	26.4	3.2	0.0	16.4	1.0	6.3	19.8	...	0.0	0.0	5.4	21.3	3.8	...
August.....	1.9	5.7	0.0	4.9	0.0	27.0	11.9	0.0	9.9	2.0	3.9	20.0	...	0.0	2.7	13.1	9.4	4.1	...
September...	6.0	3.7	0.0	8.3	147.2	37.6	29.1	0.0	13.1	37.5	4.7	0.0	...	0.0	0.0	15.4	1.8	48.9	...
October.....	2.3	1.7	0.0	1.2	7.4	15.8	33.6	7.2	10.2	14.9	1.0	12.7	...	0.0	0.0	10.2	1.8	0.0	...
November....	2.5	1.7	7.7	3.1	0.0	20.8	43.4	2.1	0.0	1.6	3.5	4.3	...	0.0	32.5	0.0	7.3	0.0	...
December...	1.3	1.1	0.0	4.5	0.0	15.4	29.8	0.0	3.2	3.7	200.2	0.0	...	0.0	2.6	0.0	0.0	8.8	...

TABLE 2—ANNUAL TOTAL TURNOVER RATES OF MEN AND WOMEN BY MONTHS

MONTH	FIRM 1		FIRM 2		FIRM 9		FIRM 10		FIRM 12		FIRM 17		FIRM 19	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
<i>1922</i>														
January.....	30.3	30.0	....	....	54.8	75.0	57.4	89.4	84.4	75.1	95.4	105.2	7.0	9.8
February.....	17.9	3.8	....	....	24.7	80.0	51.3	117.4	99.0	63.2	123.2	93.4	26.0	154.5
March.....	20.2	33.3	25.3	53.8	90.6	210.0	76.1	158.2	132.9	79.2	40.4	59.2	53.3	42.7
April.....	11.2	31.4	127.8	42.5	87.1	144.0	109.1	309.6	135.3	78.5	45.5	80.4	14.8	16.5
May.....	15.2	31.1	34.9	80.3	172.1	188.2	136.5	265.4	140.1	78.7	80.7	36.6	14.7	49.8
June.....	10.2	46.6	26.5	77.5	232.1	64.3	122.2	163.1	101.7	74.9	41.2	30.2	24.2	61.1
July.....	8.0	34.3	23.3	52.6	180.3	144.8	139.7	205.4	120.6	92.0	53.7	60.8	19.4	22.0
August.....	9.8	29.9	30.8	54.7	....	....	128.1	307.0	159.0	129.8	29.7	150.9	33.6	27.1
September....	16.7	60.4	26.1	45.8	297.1	377.8	231.3	251.2	248.0	108.7	86.1	184.6	26.6	68.4
October.....	13.2	51.7	29.6	70.0	175.0	152.7	114.3	208.7	142.1	69.1	84.2	315.2	38.7	73.7
November....	12.8	41.4	37.6	63.4	125.1	171.4	196.1	209.4	127.8	68.7	80.7	236.9	19.4	73.7
December....	15.6	28.1	33.9	40.1	142.1	20.3	143.7	270.5	457.1	127.2	61.0	124.8	16.7	40.7
<i>1923</i>														
January.....	39.9	63.8	31.9	52.9	188.5	80.0	198.2	431.7	116.4	90.0	61.8	92.3	28.3	70.0
February....	31.5	49.1	42.2	66.1	166.8	59.0	187.3	308.4	120.8	92.0	47.2	66.3	21.3	106.6
March.....	34.2	44.8	68.3	64.4	423.7	232.6	243.4	404.7	191.0	84.0	52.2	87.5	46.0	76.1
April.....	45.4	61.4	103.6	107.2	429.1	240.0	267.4	337.9	191.9	86.2	57.9	111.3	48.3	84.5
May.....	43.5	47.8	69.9	75.7	948.5	211.8	330.6	223.4	169.0	61.4	84.9	94.7	43.0	110.2
June.....	56.1	85.4	52.3	67.3	252.8	206.3	227.1	326.7	139.5	59.6	138.5	103.0	44.7	115.4
July.....	41.8	62.0	67.6	79.6	224.3	116.1	170.5	289.0	95.6	48.4	40.8	76.8	30.2	40.5
August.....	30.2	53.8	49.4	44.6	230.8	177.8	230.4	123.9	101.4	68.6	80.7	112.3	33.2	77.3
September....	38.6	86.7	64.8	99.7	188.3	49.0	186.3	192.0	152.5	89.0	70.3	105.7	56.9	126.1

October.....	22.2	43.3	72.5	127.9	100.9	98.0	196.1	90.6	138.7	42.3	75.3	129.7	54.4	129.5
November....	24.6	47.1	66.3	41.0	103.4	76.6	173.6	87.5	117.1	55.9	50.8	66.7	22.2	50.0
December....	13.5	30.6	16.0	30.9	68.1	26.1	59.8	105.3	349.5	183.5	46.4	33.7	11.0	38.6
<i>1924</i>														
January.....	41.6	74.9	21.5	41.6	52.2	0.0	116.3	126.7	91.3	68.9	26.0	41.1	22.0	38.6
February....	27.7	29.6	40.1	36.8	107.6	109.1	84.3	134.1	56.0	46.8	25.2	41.4	13.4	39.1
March.....	25.9	29.9	27.8	60.5	122.4	109.1	109.4	95.1	101.3	54.1	34.3	75.0	42.9	93.7
April.....	23.8	20.0	34.4	32.4	99.5	52.2	180.2	126.3	86.9	41.6	87.4	94.9	19.0	27.8
May.....	48.2	51.4	35.3	39.3	121.3	184.6	194.0	185.2	80.5	41.3	109.5	79.6	32.8	47.1
June.....	58.5	38.6	27.6	24.4	178.0	53.3	138.3	68.6	49.6	44.5	40.3	46.7	35.8	28.4
July.....	12.2	30.6	23.4	31.1	40.4	136.4	41.7	61.8	45.4	38.3	39.5	106.8	27.6	49.8
August.....	13.1	43.7	33.9	40.3	45.0	54.5	73.7	98.5	54.1	52.3	38.4	94.6	11.9	50.4
September...	23.5	50.0	22.5	28.8	62.5	27.3	132.8	54.5	71.1	64.9	46.3	185.4	40.9	36.2
October.....	5.8	31.1	20.9	24.6	71.4	0.0	121.6	66.1	79.4	47.1	49.4	197.4	35.9	31.9
November....	7.3	19.5	24.0	32.6	80.0	109.1	100.4	107.3	86.1	47.5	40.6	129.0	21.9	21.3
December....	10.3	50.6	27.3	23.5	75.8	0.0	115.2	145.2	379.3	137.7	46.2	42.2	19.1	10.6

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